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BRIEF RESEARCH ARTICLE

Standardized structured report for Doppler duplex ultrasound of lower extremity venous insufficiency and thrombosis: a technical note

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ABSTRACT

A standardized structured Doppler duplex ultrasound (US) report format for lower extremity venous system assessment has not been previously described. This technical note proposes a standardized, structured report for a complete Doppler duplex US protocol for evaluating lower extremity venous insufficiency and thrombosis. The protocol begins in the upper abdomen with an assessment of the heart, the ostium of the inferior vena cava (IVC), the caval hiatus, the entire course of the IVC, the iliac veins on both sides, and the entire course of the superficial and deep, perforator, and reticular venous system of the lower extremities. The diameter, compressibility, permeability, competence, velocity, thrombosis, or endothelial thickening in the transverse plane with compression maneuvers, the Valsalva maneuver, respiratory variation, and augmentation of one or both lower extremities are described according to the referring physician's request. Additional pathologic findings of varicose plexuses, incompetent perforating veins, thrombi, or surgical changes are reported. The proposed standardized structured report format, developed for educational purposes for radiologists and residents, is intended to improve accuracy and consistency of information. It also facilitates effective communication by providing relevant information to clinicians and patients.

Keywords: *Structured standardized report. Venous insufficiency. Duplex ultrasonography. Thrombosis.*

INTRODUCTION

The assessment of venous insufficiency and thrombosis of the lower extremities is one of the most common indications for Doppler duplex ultrasound (US) worldwide. The prevalence of venous insufficiency varies from 5% to 30% of the adult population with a female-to-male ratio of 3 to 11[1]. It affects approximately 20 million Americans each year[2]. Lower extremity venous insufficiency was found in 231 (66.0%) women and 119 (34.0%) men (2:1 ratio) in a preliminary report of 350 Mexican patients (personal communication). Clinical manifestations can be due to venous obstruction or valvular insufficiency[3], causing pain, swelling, edema, skin changes, and ulceration. Primary venous insufficiency is not associated with thrombosis, while secondary insufficiency is associated with obstruction and/or thrombosis; reflux leads to chronic venous hypertension in both types.

The venous system is, in many ways, far more complicated than the arterial system[4]. Effective venous return from the lower extremities requires the interaction of the heart, a pressure gradient, peripheral muscle pumps of the leg, and competent venous valves[3]. The venous system of the lower extremities includes the deep veins, which lie beneath the muscle fascia and

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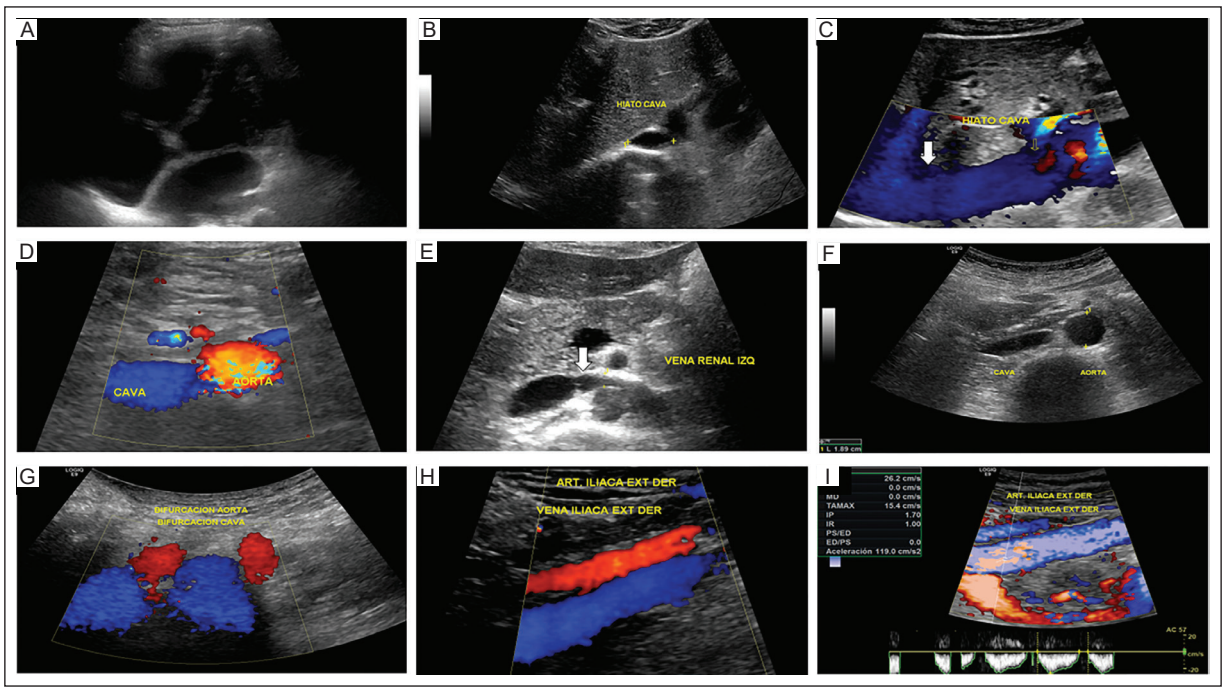

Figure 1. A: grayscale US subxiphoid approach showing the four chambers of the heart. **B:** transverse view, grayscale US showing the vena cava hiatus (3.54 cm, not shown). **C:** sagittal view, color Doppler US of the vena cava hiatus (arrow) to the root of the IVC (right atrium). **D:** transverse view, color doppler US showing normal aorta, IVC, superior mesenteric artery, and vein. **E:** transverse view, grayscale US showing the normal left renal vein (5 mm, not shown) at the junction of the aorta and superior mesenteric artery (arrow) and its junction with the normal IVC. **F:** transverse view, grayscale US of the normal aorta (1.89 cm) and IVC. **G:** transverse view, color Doppler US showing the bifurcation of the aorta and the IVC with normal patency and flow direction. **H:** sagittal view, color Doppler US of the right external iliac artery and vein showing normal patency and flow direction. **I:** sagittal view, color Doppler US and spectrum of the right external iliac vein with normal spectral morphology and velocity (26.2 cm/sec).

IVC: inferior vena cava; US: ultrasound.

drain the muscles of the lower extremities; the superficial veins, which are above the deep fascia and drain the cutaneous microcirculation; and the perforating veins, which penetrate the muscular fascia and connect the superficial and deep veins[3]. The communicating veins connect the veins within the same compartment[3].

Several authors have emphasized the importance of a standardized structured radiology report[5-7], and Mexican radiologists prefer a standardized structured report[7]. A standardized structured report of quantitative ultrasound findings, which may help to systematize the evaluation, diagnosis, and follow-up of patients with pelvic congestion syndrome or asymptomatic pelvic venous congestion, was recently published[8]. There is no standardized structured reporting format for ultrasound-based lower extremity venous system assessment. On the other hand, there is also no consensus on a defined examination protocol. The American College of Radiology recommends performing the imaging examination from the thigh to the ankle and independently assessing venous insufficiency or thrombosis[9]. Another protocol describes only examining in the standing position[10]. This technical note proposes a standardized structured report of Doppler duplex US based on a complete protocol for the assessment of venous insufficiency and thrombosis of the lower extremity.

US DUPLEX DOPPLER ACQUISITION PROTOCOL

Lower extremity venous system assessment is performed with a complete US examination protocol using different modalities: grayscale, Doppler duplex, color Doppler, power Doppler, and, more recently, B-Flow. A vascular presetting is used in the abdomen and the lower extremity venous system. The approximate duration of the full protocol is approximately 60 minutes per extremity. The complete examination protocol was developed by a radiologist (MFS) with 30 years of experience in vascular imaging.

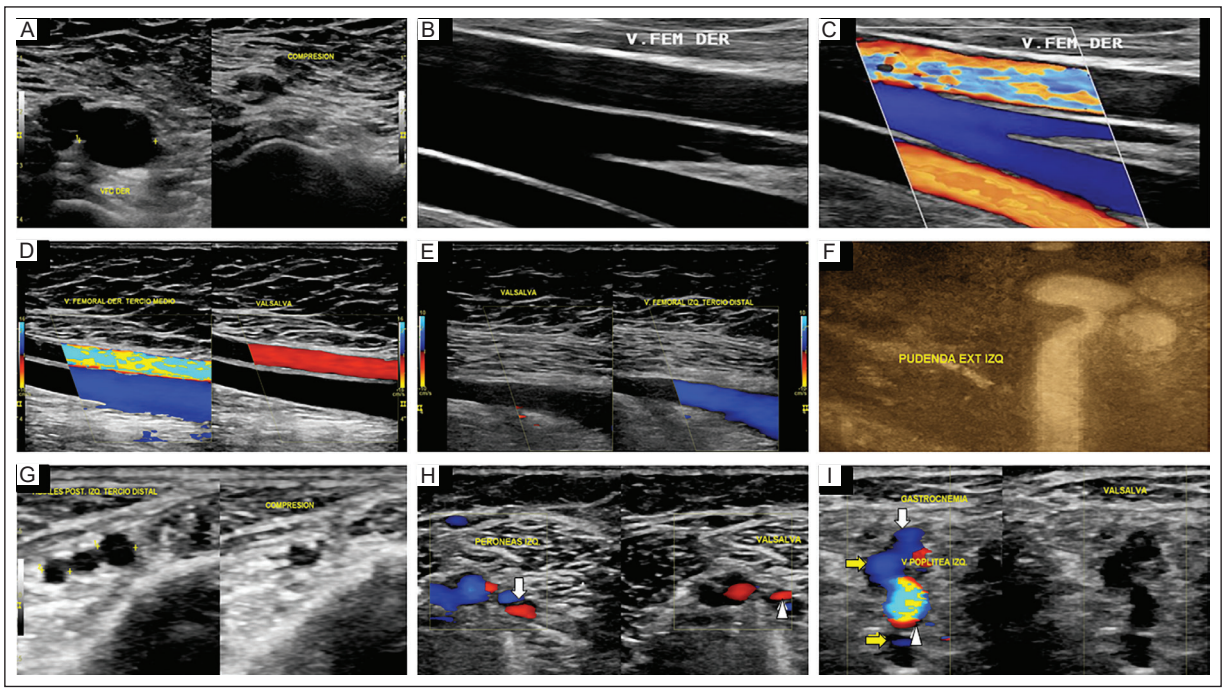

Figure 2. A: transverse view, grayscale US, the right common femoral vein is identified, with normal morphology and compressibility. **B-C:** sagittal view, the bifurcation of the common femoral vein is identified with grayscale and color Doppler US showing normal patency and flow direction. **D:** sagittal view, color Doppler US of the middle third of the right common femoral vein with normal patency and flow direction; there is no reflux during the Valsalva maneuver. **E:** sagittal view, color Doppler US of the left femoral vein in its distal third with no reflux with the Valsalva maneuver. **F:** transverse view, B-Flow US showing dilated external pudendal vein (8 mm, not shown) with retrograde flow. **G:** transverse view, grayscale US of the distal third of the left posterior tibial veins with diameters of 3.4 and 2.5 mm (not shown), normal with a complete compression maneuver. **H:** transverse view, color Doppler US of the left peroneal veins with a transverse echogenic band (arrow) in a peroneal vein, secondary to chronic thrombosis. Reflux is seen with the Valsalva maneuver (arrowhead). **I:** transverse view, color Doppler US showing the popliteal vein with a normal bifid segment (yellow arrows) and left gastrocnemius (white arrow). No reflux is observed during the Valsalva maneuver. A normal popliteal artery is seen (arrowhead).

US: ultrasound.

Respiratory variation and Valsalva maneuvers are used to evaluate the abdominal venous system with compression maneuvers in the transverse plane; augmentation, and Valsalva are performed in the reverse Trendelenburg position[4]. For insufficiency examination, the legs must be positioned below the level of the patient's head to maximize venous filling and optimize assessment of reflux[4].

The thigh and leg are examined in bipedestation when no reflux is demonstrated. All vessel diameters are recorded in the transverse plane and after the Valsalva maneuver.

Definitions

Venous reflux: retrograde flow associated with dilation during the Valsalva maneuver. A spectral inversion of > 1-second duration and a change from blue to red on color Doppler are demonstrated[11].

Incompetent perforating vein: dilatation > 3 mm with flow inversion with an abnormal direction from the deep to the superficial system.

Reverse Trendelenburg: the 45-to-60-degree tilt of the examination table in the caudal direction.

Color Doppler: the estimation and display of mean velocities relative to the direction of the ultrasound beam, interpreted as a color overlay on grayscale images.

Power Doppler: the display of scattering velocities relative to the direction of the interrogating ultrasound beam at positions throughout the image field, ignoring velocity and estimating only the strength. No direction is given.

Spectral Doppler: visual display of the audible velocity and directional shifts in blood flow.

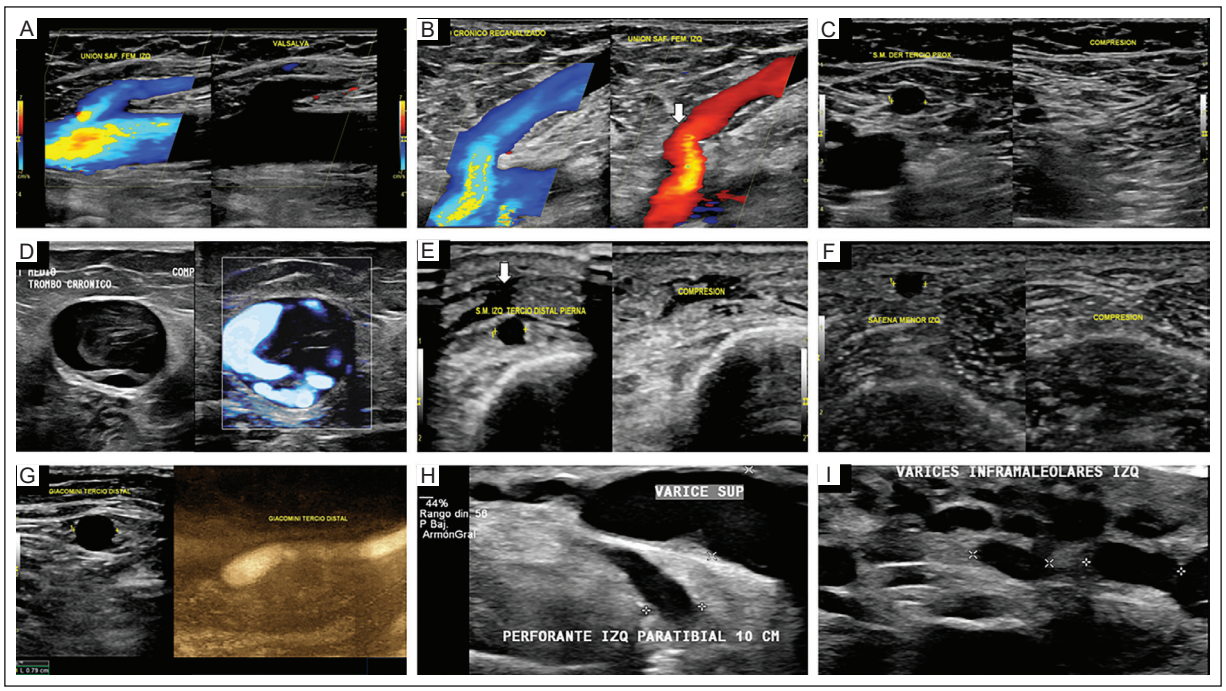

Figure 3. A: sagittal view, color Doppler US of the left saphenous-femoral junction, showing patency and flow direction. No reflux is observed with the Valsalva maneuver. **B:** sagittal view; color Doppler US of the left saphenous-femoral junction with patency and normal flow direction. Reflux is observed with the Valsalva maneuver (arrow). **C:** transverse view, grayscale US of the right great saphenous vein in the proximal third of the thigh with a diameter of 7.2 mm (not shown) and complete compressibility maneuver. **D:** transverse view, grayscale and color Doppler US of the left great saphenous vein in the middle third of the thigh with echogenic material corresponding to a chronic thrombus with partial recanalization <50%. **E:** transverse view, grayscale and color Doppler US of the left great saphenous vein in the distal third of the leg with a diameter of 4.3 mm (not shown) and complete compression maneuver. There is also mild edema of the subcutaneous tissue (arrow). **F:** transverse view, grayscale US of the left lesser saphenous vein with a diameter of 4 mm (not shown) in the middle third with complete compression maneuver. **G:** transverse view, US grayscale and sagittal view in B-Flow showing a variant of Giacomini's vein with a 7.9-mm (not shown) diameter and normal patency in B-Flow US. **H:** transverse view, grayscale US showing the left paratibial perforating vein with a diameter of 4.57 mm, located 10 cm from the inferior border of the lateral malleolus. It drains into a dilated superficial varicose vein (8.14 mm, not shown). **I:** transverse view, grayscale US of the left inframalleolar variceal bundle with 8- and 9-mm (not shown) diameters.

US: ultrasound.

B-Flow: blood flow with grayscale or B-mode US, digitally encoded wide band pulses transmitted and received to differentiate soft tissue from blood. No velocity or direction is given.

STANDARDIZED STRUCTURED REPORT FORMAT

The proposed standardized structured report format is shown in Table 1. In the case of a bilateral examination, the left lower extremity is recorded first. In the case of a unilateral examination, information on the corresponding extremity is recorded. The entire abdominal and pelvic region is always examined bilaterally, regardless of whether the lower extremity is examined unilaterally or bilaterally. The editable format of the standardized structured ultrasound report is available as a at DOI: 10.24875/JMEXFRI.M23000045.

Patient data and relevant clinical information are recorded in the report format. It is recommended that the clinician record the clinical, etiological, anatomical, and pathophysiological (CEAP) classification[6].

The assessment includes the heart, the ostium of the inferior vena cava (IVC), the suprahepatic, and entire course of the IVC, the left renal vein, the bifurcation and formation of the primitive, external, and hypogastric iliac veins; a bilateral examination is always performed in the pelvis (Figure 1). The diameter, permeability, velocity, and presence of thrombi or endothelial thickening are recorded in transverse and sagittal projections, excluding obstruction and/or extrinsic compression. The heart is examined in a transverse four-chamber plane with a subxiphoid approach because effective venous return from the lower extremities requires interaction with the heart[3]. Findings, such as thrombi, pericardial effusion, and myxomas.

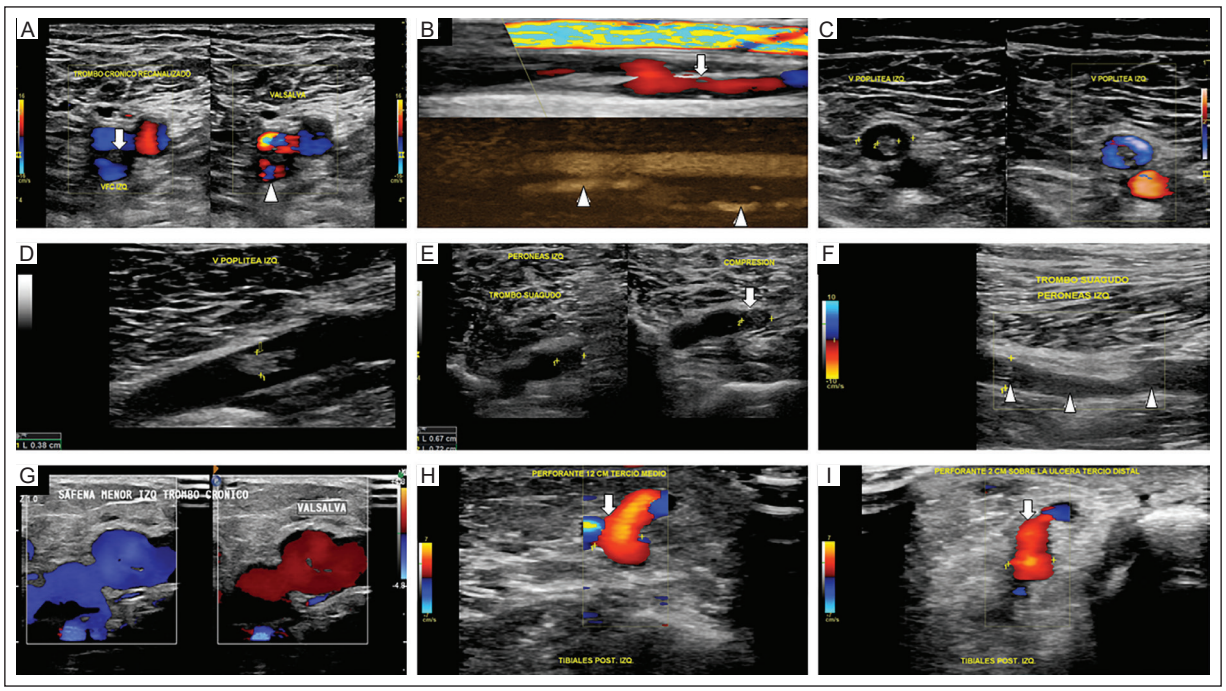

Figure 4. A: transverse view, color Doppler US of the left common femoral vein with central endoluminal echogenic material (arrow). Valsalva maneuver shows reflux secondary as a sequel of chronic thrombosis (arrowhead). **B:** sagittal view (upper image) color Doppler US of the left femoral vein in the middle third with thick endoluminal echogenic bands, central, fixed to the inferior wall due to chronic thrombosis with valvular damage and reflux (arrow). B-Flow (lower image) showing recanalization of the femoral vein (arrowheads) **C:** transverse view, grayscale US, and **D:** sagittal view, color Doppler US of the left popliteal vein with fixed central echogenic material secondary to a chronic recanalized thrombus. **E:** transverse view, grayscale US, and **F:** sagittal view, color Doppler US of the left peroneal veins with hyperechogenic, heterogeneous material in one of the noncompressible peroneal veins (arrow). Absence of flow in relation to a subacute thrombus with complete obstruction (arrowheads). **G:** transverse view, color Doppler US shows left lesser saphenous vein dilated with a 10-mm diameter (not shown). Reflux is observed with the Valsalva maneuver. **H:** transverse view, color Doppler US showing a dilated and incompetent perforator with a diameter of 6.1 mm (not shown) located 12 cm from the inferior border of the medial malleolus. **I:** transverse view, color Doppler US showing a dilated and incompetent perforating vein with a 5.8 mm (not shown) diameter, located 2 cm from the inferior border of the medial malleolus.

US: ultrasound.

The examination continues along the entire deep (Figure 2) and superficial venous systems (Figure 3). Assessment of the deep, superficial, perforating, and reticular venous systems in the thigh continues with assessment of the diameter, compressibility, permeability, competence, velocity, and presence of thrombi or endothelial thickening (Figure 3). The maximum diameter of the vessels is described in the transverse plane and after the Valsalva maneuver. Perforating veins in the thigh are designated as anteromedial, anterolateral, or posterolateral depending on their location, as is their distance in centimeters from an anatomic reference point such as the popliteal fossa. The popliteal fossa is examined with the knee flexed and in the sitting or prone position. In the leg, the location of the perforating system is described in the same way, and the distance to the medial and lateral malleolus in the ankle is determined.

Because of the complex anatomic variations of the lower venous system, it is important to know the most common variations to not confuse benign findings with pathologic changes.

Additional pathologic findings of the heart, abdomen, pelvis, and superficial and deep venous systems of the lower extremities, such as varicose veins, their location, diameter, communication with perforating veins, and thrombosis, are specifically described. In the case of abnormal perforating veins, their location and diameter are assessed. Some examples are shown in Figure 4.

The pathological findings of the abdominal region, the presence or absence of insufficiency and/or thrombosis of the deep and/or superficial venous system, and a brief description of other pathological findings are recorded as conclusions at the end of the standardized structured report format.

STANDARDIZED STRUCTURED ULTRASOUND REPORT FOR LOWER EXTREMITY VENOUS INSUFFICIENCY OR THROMBOSIS[a]

Table 1. Ultrasound examination of the venous system of the lower extremities is performed in the supine, reverse Trendelenburg, and upright positions. The following ultrasound modes are used: real time mode B, Doppler duplex, color, and power Doppler in the transverse and longitudinal planes. The following maneuvers are performed: 1. Compression in the transverse plane, 2. Valsalva maneuver, 3. Respiratory variation, and 4. Augmentation. [a]The editable format of the standardized structured report is available as a digital appendix at www.jmexfri.com.

Patient name: _____ Sex: _____ Age: _____ Date: _____

Clinical Data (CEAP)[12]:

0	1	2	3	4	5	6

Clinical diagnosis: _____

Previous procedures and examinations of the lower extremities: _____

ABDOMEN AND PELVIS

Vein	Diameter (mm)	Compressibility[a] (Yes/No)	Permeability (Yes/No)	Competence[b] (Yes/No)	Velocity (cm/sec)	Thrombosis or Endothelial thickening (Yes/No)
Inferior vena cava[c]						
Right primitive iliac						
Left primitive iliac						
Right external iliac						
Left external iliac						

[a] Since the inferior vena cava and the primitive iliac veins are deep in the abdomen, compressibility is not evaluated.
[b]Since the inferior vena cava and the primitive and external iliac veins lack valves, competence is not evaluated.
[c]The evaluation of the heart is done in a transverse 4-chamber plane and only pathological findings (thrombus, pericardial effusion, myxoma, etc.) are recorded in the additional findings section.

DEEP VENOUS SYSTEM OF THE LEFT LOWER EXTREMITY

Vein	Diameter (mm)	Compressibility (Yes/No)	Permeability (Yes/No)	Competence[a] (Yes/No)	Velocity (cm/sec)	Thrombosis or endothelial thickening (Yes/No)
Common femoral						
Deep femoral						
Proximal third femoral						
Middle third femoral						
Distal third femoral						
Popliteal[b]						
Anterior tibialis						
Posterior tibialis						
Peroneals						
Main gastrocnemic						

[a]If "yes," record the total time of reflux in seconds followed by "/" and the maximum velocity of reflux in cm/sec (example, 5 sec/20 cm/sec) [b]The popliteal vein is assessed with the patient in the prone position at the end. The patient is asked to lift the foot and rest on the toes.

SUPERFICIAL VENOUS SYSTEM OF THE LEFT LOWER EXTREMITY

Vein	Diameter (mm)	Compressibility (Yes/No)	Permeability (Yes/No)	Competence[a] (Yes/No)	Velocity (cm/sec)	Thrombosis or endothelial thickening (Yes/No)
Femoral-saphenous junction						
Greater saphenous vein						
Segment 1						
Segment 2						
Segment 3						
Segment 4						
Segment 5						
Segment 6						
Lesser saphenous vein						
[a]If "yes," record the total time of reflux in seconds followed by "/" and the maximum velocity of reflux in cm/sec (example, 5 sec/20 cm/sec).						

ADDITIONAL PATHOLOGICAL FINDINGS OF THE LEFT LOWER EXTREMITY

VARICOSE PLEXUS: indicate the presence or lack of varicose plexuses. If they exist, describe their location and if patent or thrombosed.

PERFORATING VEINS: indicate the existence or lack of incompetent perforators. Describe their maximum diameter in mm and location on the limb.

DEEP VENOUS SYSTEM OF THE RIGHT LOWER EXTREMITY

Vein	Diameter (mm)	Compressibility (Yes/No)	Permeability (Yes/No)	Competence[a] (Yes/No)	Velocity (cm/sec)	Thrombosis or endothelial thickening (Yes/No)
Common femoral						
Deep femoral						
Proximal third femoral						
Middle third femoral						
Distal third femoral						
Popliteal						
Anterior tibialis						
Posterior tibialis						
Peroneals						
Main gastrocnemic						
[a]If "yes," record the total time of reflux in seconds followed by "/" and the maximum velocity of said reflux in cm/sec (example, 5 sec/20 cm/sec).						

SUPERFICIAL VENOUS SYSTEM OF THE RIGHT LOWER EXTREMITY

Vein	Diameter (mm)	Compressibility (Yes/No)	Permeability (Yes/No)	Competence[a] (Yes/No)	Velocity (cm/sec)	Thrombosis or endothelial thickening (Yes/No)
Femoral-saphenous junction						
Greater saphenous vein						
Segment 1						
Segment 2						
Segment 3						
Segment 4						
Segment 5						
Segment 6						
Lesser saphenous vein						

[a]If "yes," record the total time of reflux in seconds followed by "/" and the maximum velocity of said reflux in cm/sec (example, 5 sec/20 cm/sec).

ADDITIONAL PATHOLOGICAL FINDINGS OF THE RIGHT LOWER EXTREMITY

VARICOSE PLEXUS: : indicate the presence or lack of varicose plexuses. If they exist, describe their location and if patent or thrombosed.

PERFORATING VEINS: indicate the existence or lack of incompetent perforators. Describe their maximum diameter in mm and location on the limb.

CONCLUSIONS:

- Abdominal pathological findings (no, or if yes, describe):
- Left lower extremity

1. Deep venous system: competent or incompetent (describe pathological segments).
2. Superficial venous system: competent or incompetent (describe pathological segments).
3. Additional pathological findings: varicose plexus, incompetent perforating veins, thrombus, surgical changes, etc.

- Right lower extremity

4. Deep venous system: competent or incompetent (describe pathological segments).
5. Superficial venous system: competent or incompetent (describe pathological segments).
6. Additional pathological findings: varicose plexus, incompetent perforating veins, thrombus, surgical changes, etc.

CONCLUSION

In this technical note, we propose for the first time a structured standardized reporting format for ultrasonographic examination of venous insufficiency and thrombosis of the lower extremities based on a complete protocol with different US modalities. A thorough knowledge of the anatomy and hemodynamics of the lower extremity venous system is essential for optimal examination. The described protocol allows obtaining a complete vascular map with morphologic and hemodynamic information about the sites of retrograde flow and venous leakage, enabling the referring clinician and surgeon to determine therapy based on the standardized structured report findings with precise and reproducible language for multicenter studies and research purposes. The standardized structured report format is intended for educational purposes to assist the radiologists and residents in performing a systematic, complete, and reproducible examination of the venous system of the lower extremities to achieve clear, accurate, and complete communication with the referring clinician and patients.

Supplementary data

Supplementary data are available online in the Journal of the Mexican Federation of Radiology and Imaging online (DOI: 10.24875/JMEXFRI.M23000045). These data are provided by the corresponding author and published online for the reader's benefit. The contents of supplementary data are the sole responsibility of the authors.

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Conflicts of interest

The authors declare no conflicts of interest.

Ethical disclosures

Protection of Individuals: This study complied with the Declaration of Helsinki (1964) and subsequent amendments.

Confidentiality of Data. The authors followed their center's protocol for sharing patient data.

Right to privacy and informed consent. The authors declare no ethical responsibilities since humans' confidential information was not used.

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