SUPPLEMENTARY DATA

How to perform inferior vena cava ultrasound

From the standard 4-chamber subcostal approach, the transducer is turned counterclockwise with the index mark pointed in the direction of the patient's head. The transducer is then tilted medially, and the long-axis of the inferior vena cava (IVC) will come into view. The diameter will be measured perpendicular to the long axis of the IVC at end-expiration, just proximal to the junction of the hepatic veins that lie approximately 0.5 to 3.0 cm proximal to the ostium of the right atrium.

How to assess the jugular vein by ultrasound

With the patient's head elevated at 45º, the right internal jugular vein (IJV) can be imaged at the triangle's apex formed by the sternal and clavicular heads of the sternocleidomastoid muscle by placing a high-frequency linear probe (~10 MHz) in the transverse plane on the patient's neck. Subsequently, the ratio between the IJV diameter at rest (expiratory phase) and its changes during Valsalva is measured by M-mode (diameter during Valsalva/ diameter at rest).

How to perform hepatic vein flow

The transducer is angled medially from the standard 4-chamber subcostal approach until the inferior vena cava is seen entering the right atrium. Subsequently, the hepatic veins will be brought into view with a slight medial and lateral angulation. Usually, the middle or right hepatic vein is visualized. Finally, the pulsed-wave Doppler sample volume will be placed within the vein approximately 1 to 2 cm from the inferior vena cava junction. Forward flow (toward IVC and away from the transducer) is seen below the baseline, and retrograde flow (away from IVC and toward the transducer) is seen above the

baseline. HV waveforms should be analyzed during apnea, given that respiration influences intrathoracic pressures and Doppler signals may be altered.[1]

How to assess portal vein flow by ultrasound

The portal vein is the main vessel of the portal venous system and drains the blood from the abdominal organs to the central circulation (IVC) after its passage through the liver. The hepatic sinusoids connect the portal veins with the hepatic arteries and veins. In the normal state, the arteries do not contribute significantly to portal pulsatility, whereas changes in RA pressures influence portal venous flow first through the hepatic veins, then to the hepatic sinusoids, and ultimately to the portal circulation.

With the patient in supine decubitus and quiet respiration, a color-Doppler examination of the main portal vein can be imaged by placing the probe in the mid to posterior axillary position at the 9th to 11th intercostal spaces[2] (figure 1 of de supplementary data). Subsequently, the pulsed-wave Doppler sample volume is placed within the vein approximately 2 cm below its bifurcation to obtain the portal venous flow[2] (figure 1 of de supplementary data). Blood flow velocity in the portal vein usually ranges from 10 to 30 cm/s, so the Doppler scale should be adjusted to obtain the best velocity differentiation with minimal noise (usually in the 15-30 cm/s range).

The normal portal venous waveform pattern should be continuous or slightly undulated. The peak portal velocity (V_1) corresponds to systole and the trough velocity (V_2) to end-diastole (atrial contraction). The degree of undulation can be quantified using the portal pulsatility index (PPI) [(V_1-V_2)/V_1] as follows:

- Portal pulsatility index < 30%: 0 (normal)
- Portal pulsatility index 30-49%: 1 (mildly abnormal)
- Portal Doppler index > 50%: 2 (severely abnormal)

How to perform renal venous Doppler ultrasound

The kidneys are examined with the patient in the supine or lateral decubitus position using a convex or sector transducer (2.5-5 MHz). Preferably, longitudinal and transverse scan planes are recommended. Using color Doppler with the flow scale adjusted to low-flow velocities (15-20 cm/s), the interlobar vessels are identified at the corticomedullary transition (parallel to renal pyramids) (figure 2 of de supplementary data). Subsequently, spectral Doppler is performed with a small sample volume to obtain flow information from only 1 vessel of interest (figure 2 of de supplementary data). The scale should be adjusted, maximizing the amplitude of the signal (usually around −20 cm/s), and the electrocardiographic signal should be displayed to synchronize the renal venous flow signal with the cardiac cycle (figure 2 of de supplementary data).

There are 3 different ways to interpret intrarenal venous flow (IRVF):

- The first method categorizes the IRVF signal into 3 flow patterns[3]: continuous (normal), biphasic discontinuous (Doppler signal in systole and diastole—moderate congestion), and monophasic discontinuous (diastolic-only flow pattern— severe congestion).

- The second method evaluates the venous impedance index,[3] which is calculated by dividing the difference between the peak and nadir velocities of venous flow by the peak velocity. However, this method does not discriminate between biphasic and monophasic patterns (nadir flow velocity = 0), in which the ratio is 1 in both cases.

- The third method is the renal venous stasis index,[4] which indicates the proportion of the cardiac cycle during which there is no renal venous outlet flow. It is calculated as follows: (cardiac cycle time−venous flow time)/cardiac cycle time. The lowest the proportion of the cardiac cycle in which there is outlet venous flow, the greater the severity of renal congestion (figure 3 of de supplementary data).

How to perform lung ultrasound

During LUS examination, patients are positioned either sitting upright, semirecumbent, or supine. By using the anterior axillary line as a landmark, each chest wall can be divided into 4 lung regions (upper

and lower parts of the anterior and lateral chest wall). Subsequently, a phased-array or curvilinear transducer is placed in an intercostal space in a chest zone either perpendicular or in parallel orientation to the ribs, with an imaging depth of 14 cm. B-lines are defined as a discrete laser-like vertical hyperechoic reverberation artifact that arises from the pleural line, extends to the bottom of the screen without fading, and moves synchronously with lung sliding. For B-line quantification, 2 general approaches are valid[5,6]:

- A count-based method, in which the sum of B-lines in 1 intercostal space per zone across all zones is reported.
- A scoring system in which a minimum number of B-lines in 1 intercostal space per zone is used to define a zone as "positive". Positive zones are then summed to delineate a cutoff value score-based method. For example, ≥ 3 B-lines in 3 zones on each hemithorax are consistent with a diagnosis of pulmonary edema in dyspneic patients presenting to the emergency department.[7]

REFERENCES

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Figure 1 of the supplementary data. Portal vein assessment.

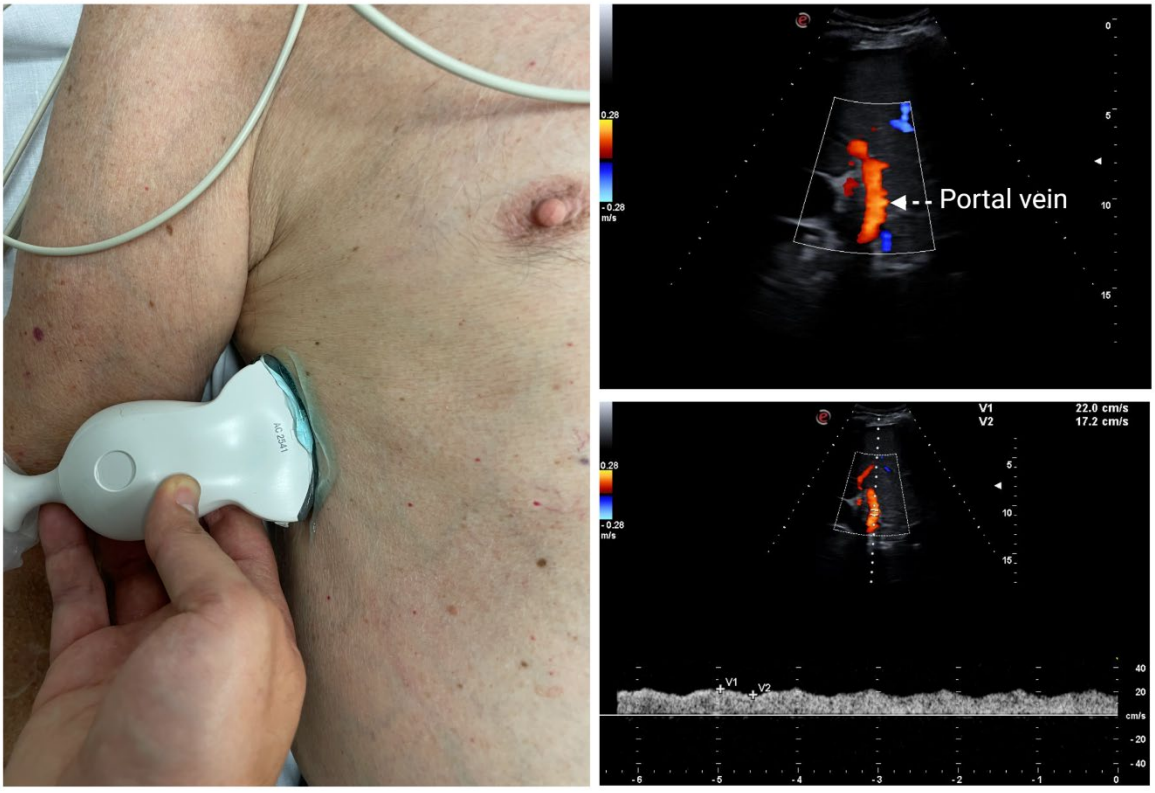


Figure 2 of the supplementary data. Intrarenal venous flow assessment.

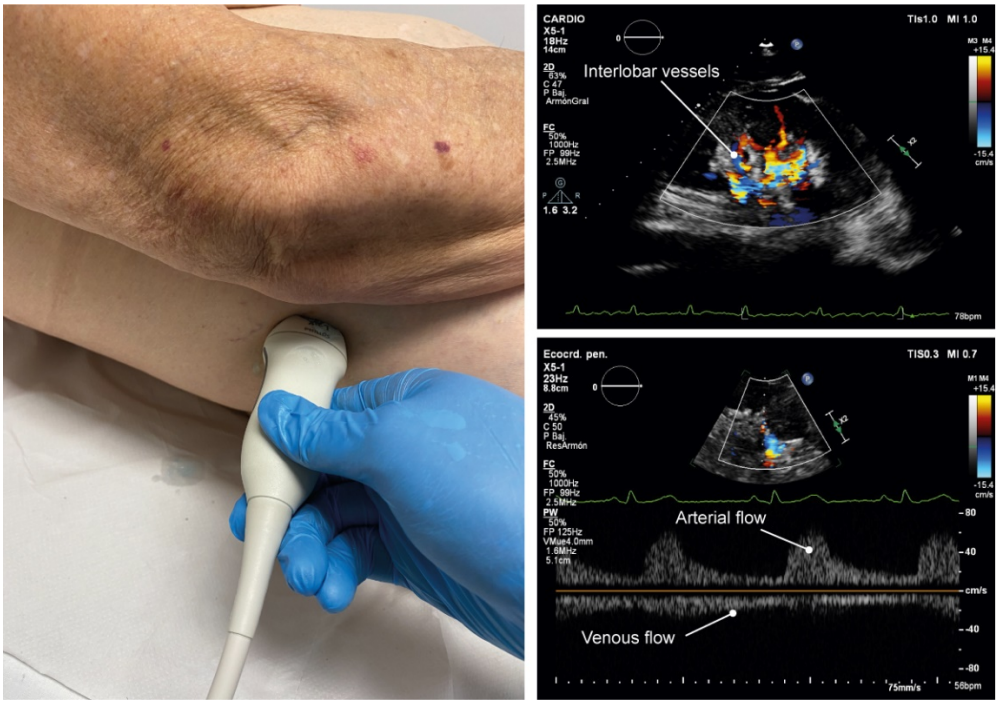
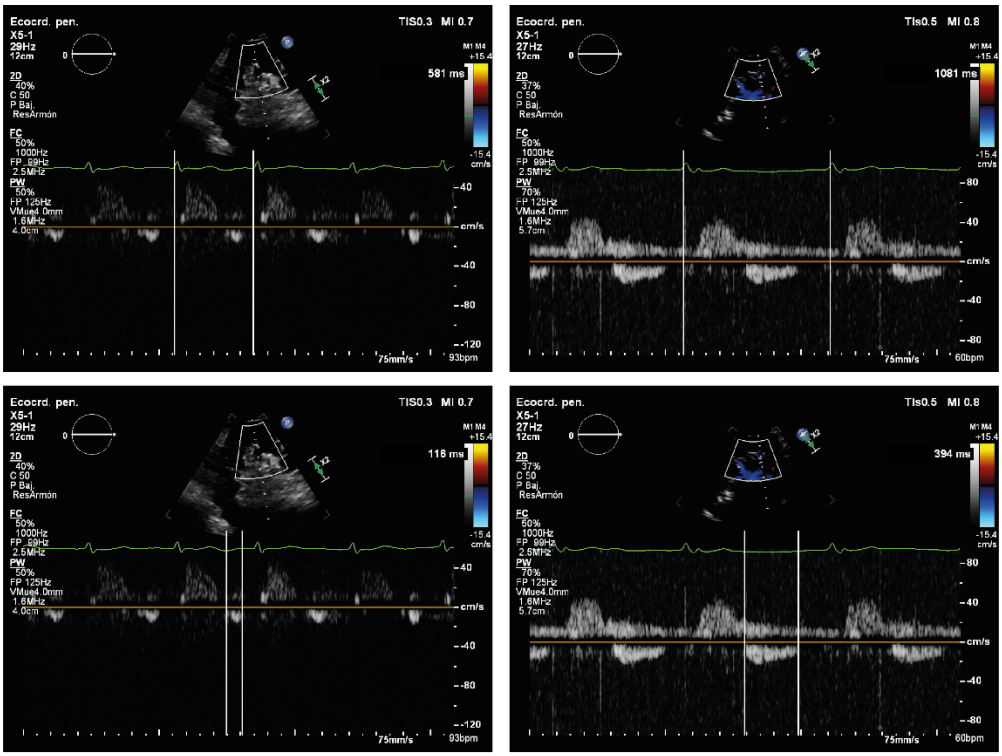


Figure 3 of the supplementary data. Renal venous stasis index.



Patient 1:
Renal venous outlet flow: 20% of cardiac cycle

Patient 2:
Renal venous outlet flow: 63% of cardiac cycle

$$\textbf{Venous stasis index} = \frac{\text{cardiac cycle time (ms)} - \text{venous flow time (ms)}}{\text{cardiac cycle time (ms)}}$$