Internal and Emergency Medicine
https://doi.org/10.1007/s11739-025-03898-3

EM - REVIEW

# Point of care ultrasound for monitoring and resuscitation in patients with shock

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Received: 8 June 2024 / Accepted: 10 February 2025


**Abstract**
Point-of-Care Ultrasound (POCUS), when used by experienced physicians, is a valuable diagnostic tool for the initial minutes of shock management and subsequent monitoring. It enables early diagnosis with high sensitivity (Sn) and specificity (Sp). Published protocols have advanced towards true multi-organ ultrasonographic exploration, with the RUSH (Rapid Ultrasound in Shock) protocol likely being the most well-known nowadays. Although there is no established order, cardiac evaluation, as well as vascular system assessments including intra- and extravascular volume, should be explored. Additionally, there are ultrasonographic evaluations particularly useful for diagnosing and monitoring response/tolerance to volume. Both the identification of B lines and the increase in left ventricular pressures bring us closer to a diagnosis of fluid overload in these patients. Velocity–time integral (VTI) of the left ventricle (LV) outflow tract (LVOT, $LVOT_{VTI}$) or right ventricular outflow tract (RVOT, $RVOT_{VTI}$) can be indicative of distributive shock if elevated, and help identifying volume responders through leg-raising manoeuvres or crystalloid bolus administration. Several index of the inferior vena cava (IVC) can also be helpful. In addition, different parameters to establish fluid responsiveness are being investigated at the carotid level. Venous congestion parameters have not yet been proven to identify volume responders but can identify patients with poor tolerance. Currently, it is essential that physicians treating critical patients use POCUS to enhance clinical outcomes.

**Keywords** Shock · POCUS (Point Of Care Ultrasound) · Velocity · Time integral (VTI) · Monitoring, B · Lines · Inferior vena cava (IVC) · Carotid · VExUS

## Introduction

Shock is a medical emergency characterized by circulatory failure that results in inadequate tissue oxygenation and perfusion. POCUS offers the advantage of being performed at the bedside by the same medical team treating the patient and allows a quicker and more accurate assessment and treatment. According to the European Sepsis Occurrence in Acutely Ill Patients II (SOAP II) trial, the types of shock include obstructive (2%), cardiogenic (17%), distributive

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Published online: 03 April 2025

(62%), and hypovolemic (16%), which often overlap [1]. Since 2014, the European Society of Intensive Care Medicine has recommended the use of POCUS in managing shock [2].

Jones et al. [3] demonstrated in a randomized study conducted in the emergency department (ED) that using ultrasound earlier in a shock situation leads to a faster and more reliable diagnosis. Subsequently, Shokoohi et al. [4] also showed how the use of ultrasound changes resource management and utilisation. Although there are various studies highlighting the utility of POCUS in accelerating etiological diagnosis, assessing cardiac function, cardiac output, and predicting fluid responsiveness, there is much less evidence in clinical outcomes [5]. A study in shock patients compared a retrospective non-ultrasound-guided group with a prospective POCUS-guided group in the intensive care unit (ICU). They showed that POCUS-guided patients had greater fluid restriction and vasoactive drug use, better survival (66% vs. 56%, $p = 0.04$) and less renal injury [6], with similar results in subsequent studies [7, 8]. These data highlight the potential clinical impact of POCUS in the assessment of shocked patients. In this review, we will address all aspects of POCUS that the physician dealing with critically ill patients should be aware of.

## Usefulness of POCUS in the diagnosis of shock: the golden ten minutes

The first ten minutes of clinical assessment in shock patients are critical for proper diagnosis and initiation of appropriate treatment. Ultrasound has proven to have sufficient sensitivity and specificity in diagnosing shock. Sensitivity varies from 78% in cardiogenic shock, 79% in distributive, 80% in mixed, and 82% in obstructive; even reaching 90% in hypovolemic shock. Moreover, the specificity is 95% [3, 9], except in distributive shock. However, there is still no standardised method for managing shock.

Many protocols focusing on multi-organ scanning have been developed in recent years, with the RUSH protocol currently being the most widely used [9–11]. This protocol conceptually represents the main systems involved as the *pump* (cardiac function), *tank* (effective intravascular volume), and *pipes* (vascular system). The *pump* refers to cardiac function, focusing on the pericardial cavity followed by the function of the LV and comparing its size with the right ventricle (RV). The *tank* section refers to the effective intravascular volume and focuses on the inferior vena cava (IVC), internal jugulars, and their dynamics with respiration. It also includes lung assessment to demonstrate pneumothorax, pleural effusion, and B-lines, suggestive of fluid overload. Finally, the *pipes* section refers to the vascular system. It first assesses the thoracic and abdominal aorta, and then evaluates the deep venous system to search for thrombosis.

In a meta-analysis conducted by Keikha et al. [12], the area under the curve (AUC) for the RUSH protocol was excellent overall (0.98 ± 0.01). Although it is a comprehensive protocol with high diagnostic sensitivity (Sn 0.87, 95% confidence interval (95% CI): 0.80–0.92) and specificity (Sp 0.98, 95% CI: 0.96–0.99), this protocol is not yet considered a standardized method for the management of shock.

## Ultrasound management strategy

We propose the following POCUS strategy which is represented in Online Resource 1.

1. *Excluding Obstructive Shock*: We suggest beginning the ultrasound evaluation with a subxiphoid four-chamber view using a sector probe. The subxiphoid plane allows for rapid detection of tamponade signs (collapse of the right atrium (RA) and RV in diastole and septal shift towards the LV) along with a plethoric IVC by rotating the transducer to a longitudinal plane [13]. It also enables the detection of signs of massive pulmonary embolism (PE), with a dilated, dysfunctional RV and septal shift towards the LV, and again, a plethoric IVC. In either scenario, if there is a correlation with the clinical examination, the physician should individualize the directed treatment.

2. *IVC Assessment*: Subsequently, we complete the examination of the IVC diameter and its collapsibility with the same sector probe in a longitudinal plane, measuring 2 cm from the entrance of the RA. These parameters can help to assess the volemic status of our patients where a dilated IVC with < 50% collapsibility suggests hypervolaemia and a filiform IVC with > 50% collapsibility may demonstrate hypovolaemia. Before taking any therapeutical decisions according to IVC measurements we have to take into account the possibility of confounding conditions in our patients that will be explained further in this manuscript [14, 15].

3. *Assessment of LVOTVTI, the Global Cardiac Function, and Presence of Severe Valvular Heart Disease*: This step is necessary in any type of shock, and in fact, cardiac assessment is the only common component across all shock evaluation protocols. A four-plane echocardiography (parasternal long and short axis, four and five chambers) is necessary.

The first objective is the detection of distributive shock through the identification of an LVOTVTI greater than 18 cm [16]. Additionally, this value will be used as a reference to assess fluid responsiveness during echocardiographic monitoring [17]. Other objectives include the detection of cardiogenic shock, or shock with a cardiogenic component associated. In the hands of experts, a subjective visual assessment of left ventricular function is usually sufficient [18], although other methods like the triplane Simpson's method can be used if the visualization of the endocardium is adequate. Typically, septic cardiomyopathy will exhibit global dysfunction or apical ballooning, which is suggestive of stress cardiomyopathy or Takotsubo [11]. Hypoperfusion can also produce hemodynamic infarctions in patients with underlying pathology, presenting as segmental contractility alterations following coronary distribution and potentially affecting overall cardiac function. Visual assessment of the valves should not be overlooked at this stage. If severe aortic stenosis is suspected based on auscultation findings (systolic murmur radiating to the carotids and obliteration of the second heart sound) or two-dimensional assessment in the parasternal long and short axis, further evaluation with continuous Doppler is necessary. While a formal evaluation should be performed by a specialist cardiologist, bedside clinicians must approximate the severity of this condition due to its hemodynamic implications. Therefore, at the very least, they should perform a screening using peak jet velocity ($\geq$4.0 m/s) and the mean aortic transvalvular pressure gradient ($\geq$40 mmHg) [19]. Although recommended for all windows, this should initially be done in a five-chamber view using Continuous Doppler, parallel to the flow (avoiding Colour Doppler and angle changes), with an x-axis time scale of 50–100 mm/s, high-level wall filters and low gain. The maximum velocity is measured at the outer edge of the dark signal, excluding fine linear signals. The outer edge of the spectral Doppler envelope is traced to provide both the velocity–time integral (VTI) for the continuity equation and the mean gradient. Another potential finding is mitral valve rupture, which should be assessed using Colour Doppler at this stage.

4. *Lung Ultrasound*: By switching to a convex probe, we will perform a lung ultrasound, which will include at least two points of every lung (extendible at the clinician's discretion and other findings): the upper anterior plane at the mid-clavicular level and the posterobasal point. The former will reasonably rule out the presence of pneumothorax if there is pleural sliding (if in doubt, a linear probe can be used). The latter will rule out the presence of pleural effusion which may indicate hemothorax or heart failure depending on the clinical context [20].

5. *Abdominal Assessment*: Using a Focused Assessment with Sonography in Trauma (FAST) protocol (right, left coronal, and suprapubic longitudinal and transverse planes) and assessing the abdominal aorta, we will detect the presence of free fluid and rule out, as much as possible, a ruptured abdominal aortic aneurysm [21]. In the case of a woman of childbearing age, a ruptured ectopic pregnancy should also be considered.

6. *Additional*: The rest of the ultrasound evaluations can be left to the discretion of the attending physician, depending on the clinical situation, ensuring not to delay reperfusion treatment.

– Once PE is suspected, to further assess cardiac impact, the tricuspid annular plane systolic excursion (TAPSE), *s′* with tissue Doppler (DTI), the maximum velocity of tricuspid regurgitation (TR), the size of the RA, or the presence of a midsystolic notch in the right ventricular outflow tract should be evaluated [22].
– Performing a simplified three-point ultrasound of the lower limbs, we can detect the presence of deep vein thrombosis (DVT) in more than 50% of cases of PE [23]. **More** information in Online Resource 2.
– A suprasternal view can be useful for assessing the thoracic aorta if acute aortic syndrome is suspected. If the patient cannot be moved to a computed tomography scan, a transesophageal echocardiography may be needed in this situation [23].
– Septic shock, as the most common type of shock, is a clear example of a pathology whose mortality depends on timely intervention [24] and where early POCUS can provide the greatest benefits. The clinical and laboratory diagnosis can be challenging due to the insufficient sensitivity and specificity of symptoms, signs, and analytical parameters or biomarkers, [25] especially in certain populations such as elderly, obesity or multimorbid patients. Ultrasound can identify the source of infection in 15% of patients, according to an observational series [26] and significantly increases the sensitivity and specificity compared to clinical impression (Sn 73% vs. 48%, Sp 95% vs. 48%, respectively [27]). POCUS also appears to be more sensitive than X-ray for the detection of pneumonia (86.2% vs. 28.6%, $p < 0.001$), and this is likely to increase in shock patients since portable X-rays are usually taken in a single projection [28]. Renal and bladder assessment is essential especially in the differential diagnosis of oligoanuria. The detection of a bladder balloon in the presence of prostatitis symptoms may justify bladder catheterization, and hydronephrosis should suggest a urinary origin of sepsis, indicating the need for source control through drainage [29]. In addition, in the gastrointestinal evaluation, if gallstones are not observed, the negative predictive value (NPV) for the presence of cholecystitis is 100% [30], it can also detect liver abscesses or intestinal findings suggestive of bowel ischemia. POCUS allows better detection of skin abscesses [31], but the suspicion of necrotizing fasciitis will always be clinical. The detection of endocarditis by transthoracic echocardiography usually occurs in severe cases and is evidenced by leaflet destruction and valvular incompetence (regurgitation). Additionally, as discussed below, septic shock is an entity where POCUS is particularly relevant in monitoring fluid response and tolerance [11].

## Echocardiographic assessment of cardiac output

The assessment of cardiac output (CO) in shock is necessary from the outset, as it allows for better classification of the type of shock and enables subsequent echocardiographic monitoring. This is crucial because volume resuscitation is often already being initiated during the initial ultrasound. Indeed, some authors have discussed expanding the RUSH protocol to RUSH-VTI, as a strong correlation has been found between CO measurement by ultrasound (Fig. 1) and thermodilution in the pulmonary artery [32, 33].

Measurement of the LV CO is complex and involves multiplying the stroke volume (SV) by the heart rate (HR). In turn, the SV is the product of the area of the LVOT and the VTI of the flow obtained using Pulsed Wave Doppler (PW-Doppler) in either a five-chamber or three-chamber view.

- The area of the LVOT is calculated in the long-axis parasternal plane using the circle area formula ($\pi \cdot r^2$), where 'r' is half the distance measured from inner-to-inner edge at the LVOT, approximately 3 to 10 mm from the aortic valve during mesosystole.
- The VTI is obtained by placing the sample volume of the pulsed PW-Doppler 3–10 mm proximal to the aortic valve, capturing the flow wave during systole. Tracing this wave from the baseline to the peak allows for the calculation of the VTI, a critical parameter for continuous monitoring [34].

Considering the challenges and potential for error in measuring the diameter of the LVOT, especially when squaring these measurements, it has been suggested to simplify the process using only the LVOTVTI as a surrogate indicator of CO, since the diameter of the LVOT remains constant for each patient. In healthy individuals, the LVOTVTI generally ranges from 18 to 22 cm. A value less than 18 cm indicates low cardiac output, suggesting obstructive, hypovolemic, or cardiogenic shock. Conversely, a value greater than 18 cm may indicate distributive shock [16]. It is essential to recognize situations that can alter the VTI, such as dynamic LVOT obstruction with anterior mitral systolic motion, significant aortic regurgitation, subaortic stenosis, and the presence of prosthetic valves. Furthermore, in cases of atrial fibrillation, an average of at least five beats should be performed.

## Detection of fluid responders through fluid challenge or leg raising test

In cases of sepsis, due to the disproportionate reaction to the infection, only about 50% of patients adequately respond to bolus fluid therapy, and of those, half will eventually stop responding [35]. Fluid overload can increase the risk

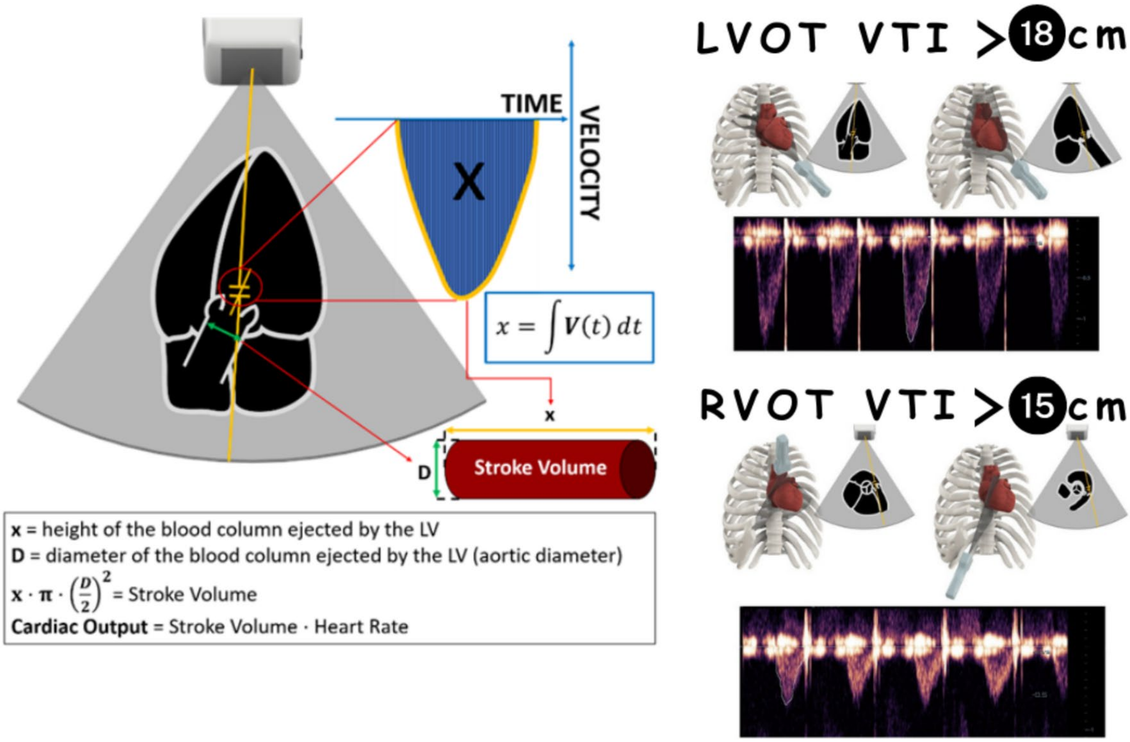


**Fig. 1** Simplification of left ventricular (LV) cardiac output through the measurement of the Velocity–Time Integral (VTI) from the left ventricular outflow tract (LVOTVTI). This technique can also be applied to the right ventricular outflow tract (RVOTVTI)

of mortality and significant renal damage [36], making it essential to detect non-responders for the early initiation of vasoactive drugs. Additionally, it is important to note that the examination should be repeated as many times as necessary due to the dynamic clinical course of shock.

Before discussing how to detect fluid responsiveness, we need to know what is meant by a fluid responder. Fluid responsiveness is defined as an increase in stroke volume of > 10% following a fluid challenge [37]. Different ultrasound parameters can be used to predict it.

## Detection using the LVOTVTI and the RVOTVTI

The use of the fluid challenge or leg raising test has become popular for detecting fluid responders. This technique is considered effective if the CO or the LVOTVTI or RVOTVTI increases by at least 15% after administering 250–500 ml of crystalloids [38] or after performing a leg raise while avoiding the potential deleterious effects of fluid overload (Fig. 2). The leg raise is presumed to increase the preload by 250–500 ml by placing the patient in a supine position and elevating the lower limbs to at least 45º for 13 min from a semi-recumbent position. This test is considered highly reliable, with a sensitivity of 85% and a specificity of 91% for detecting fluid response [17, 39].

Finally, the adaptability of the monitoring and diagnostic technique to the patient's anatomy is crucial, especially in cases where standard echocardiographic windows are not applicable. In such situations, the RVOTVTI, similarly measured in a short-axis parasternal or more feasibly in a subxiphoid short-axis view, can serve as an adequate surrogate for assessing the right ventricular CO and monitoring the clinical response, with normal VTI values being above 15 cm [34, 40] (Fig. 1).

## Detection using carotid PW doppler

Carotid PW-Doppler assessment has sparked interest in shock monitoring and predicting volume responsiveness (Fig. 3) [41]. However, it is not a standardized assessment, and although it is an accessible and easy-to-perform plane, the need for expertise for accurate measurements, and the

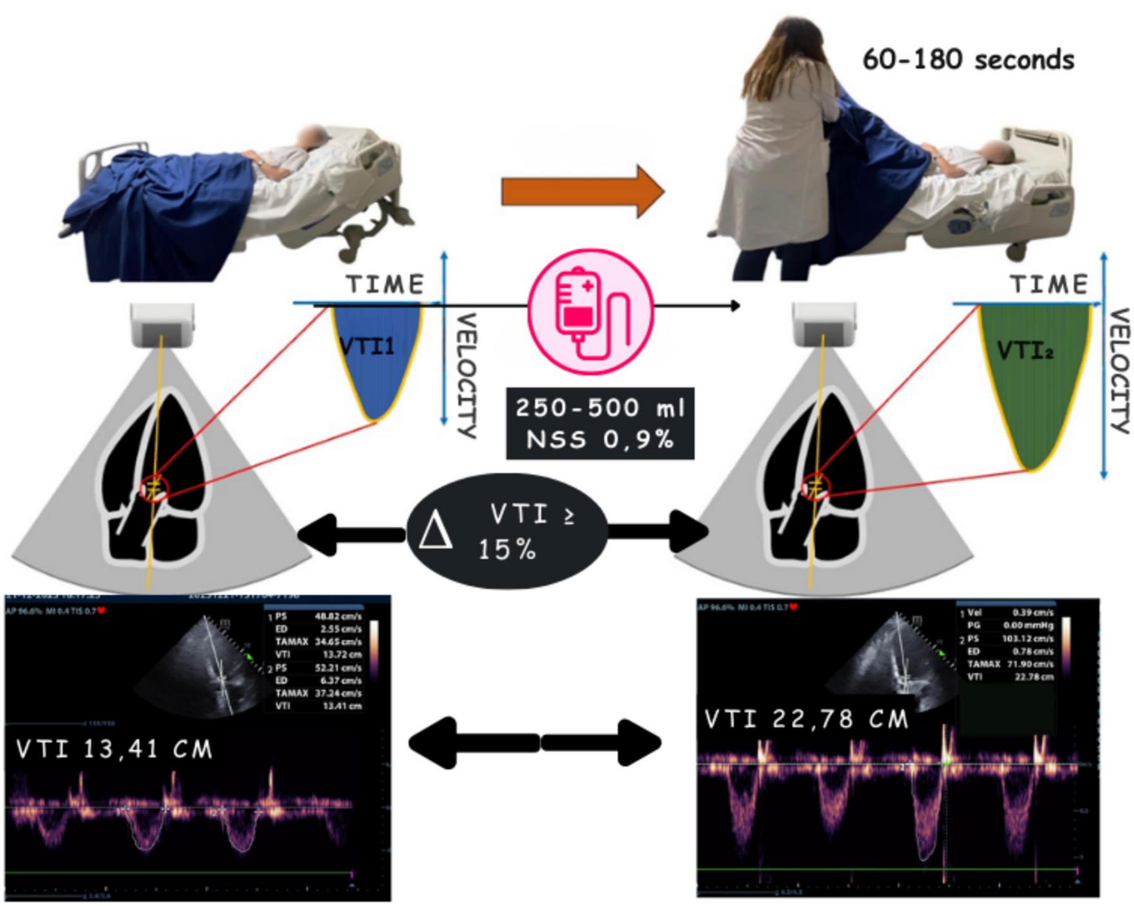


**Fig. 2** Calculation of the Velocity–Time Integral (VTI) following a volume stress manoeuvre (leg elevation for 60–180 s or administration of 250–500 ml of normal saline (NSS 0.9%) in bolus

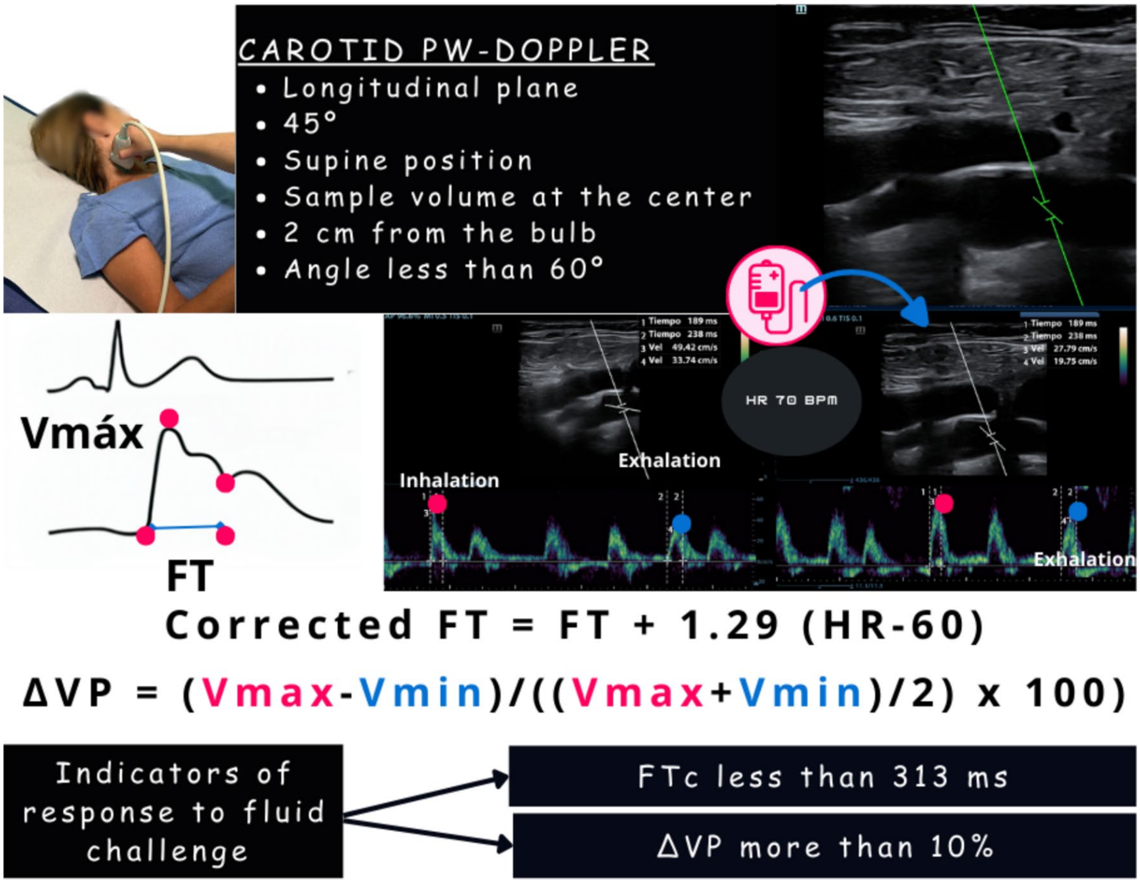


**Fig. 3** Technique for acquiring PW Doppler images of the carotid artery and formulas for calculating corrected flow time (FTc) and peak systolic velocity variability (ΔVP). Fluid responsiveness criteria. A patient meeting the criteria for volume responsiveness is shown. Vmax, Vmin = maximum and minimum velocity

limitation posed by the presence of carotid stenosis or other anatomical issues, make its applicability more challenging.

Multiple carotid parameters have been studied, among which the corrected carotid flow time (FTc) and the variability of peak systolic velocity (ΔVP) stand out.

FTc is the duration of LV ejection, and it is measured in common carotid. FTc can be assessed as an absolute value before and after the fluid response manoeuvre, or by its percentage change. A meta-analysis has shown that FTc before treatment lower than 349 – 313 ms (being lower in spontaneously breathing patients) have a combined sensitivity of 76% and specificity of 88% for predicting fluid responsiveness [42]. A FTc difference after fluid challenge (ΔFTc) of 7 ms to determine fluid responsiveness has a sensitivity of 68% and a specificity of 96%. A variation of more than 9–26%, according to other studies, shows a sensitivity of 81–95% and a specificity of 66–95% [42, 43].

ΔVP is the variation in peak systolic velocity during inspiration-expiration. It has been studied primarily in septic shock or in surgical settings, especially in intubated patients, and is recommended as a method of continuous non-invasive monitoring. It is important to consider that intrathoracic pressure variations in intubated patients differ from those in spontaneous breathing. A 14% ΔVP has a combined sensitivity and specificity of 83% and 81%, respectively, with greater homogeneity of results in a meta-analysis [44, 45].

Despite the controversy and lack of validation, our group proposes the assessment of carotid flow as an alternative method for evaluating fluid responsiveness in patients where more conventional methods, such as LVOTVTI or IVC, cannot be used. Although there is no standardized system, PW-Doppler assessment is performed in a longitudinal plane, with the patient in a supine position at 45°, and the sample volume placed at the center of the carotid artery, two centimetres from the bulb, with an angulation of less than 60°. FTc is measured in the Doppler spectrum analysis, from the beginning of the ascending curve to the notch at the end of systole and should be corrected for heart rate variability using either the Bazett´s or Wodey´s formula. The ΔVP is calculated by measuring the maximum and minimum systolic velocity throughout the respiratory cycle. During a fluid challenge, we consider a basal FTc less than 313 ms and a

ΔVP greater than 10% to be markers of a high probability of fluid responsiveness, although these assumptions should be approached with caution.

## Detection using IVC

IVC ultrasound is performed in the subxiphoid longitudinal plane using a convex probe (Online Resource 3). The measurement is taken 2 cm from the entrance to the RA either with B or M-mode. An IVC diameter of less than 2 cm with more than 50% collapse on deep inspiration has been shown to have considerable sensitivity and specificity in identifying patients in need of fluid therapy (distributive or hypovolemic shock) [46–48]. Nevertheless, we need to be aware of the anatomical and physiological aspects that can affect its interpretation such as: chronically dilated IVC in younger athlete patients, children with increased venous compliance, vasoplegic effect of drugs or sepsis among other. Changes in intrathoracic pressure, due to usual respiration, modify its diameter cyclically [49]. Also, diseases such as severe tricuspid regurgitation, right ventricular failure, acute PE, pericardial effusion or tamponade, chronic obstructive pulmonary disease, intraabdominal hypertension including pregnancy or patients on mechanical ventilation can lead to a misinterpretation of IVC measurements. Collapsibility of IVC can be reduced in hypoproteinaemia situations such as malnutrition, cancer, sepsis or cirrhosis but the patients are truly hypervolemic due to a third space. We cannot forget that masses near IVC can mimic collapsibility or dilatation of the vein. All of these characteristics make the assessment of IVC more complex than it seems and have raised doubts about the utility of this vessel as a hemodynamic response monitor [14, 50].

Correlation between IVC diameter and response to fluid therapy has only been accurately described in patients fully connected to mechanical ventilation without any inspiratory effort of their own. This has been represented by two formulas under the name of "distensibility index" (dIVC) = [(Dmax—Dmin) / Dmin] × 100 and "respiratory variation on IVC diameter" (ΔDIVC) = [ (Dmax − Dmin) / [(Dmax + Dmin) / 2] × 100. Several studies have concluded that if dIVC reaches or exceeds 18%, it can discriminate with a sensitivity and specificity of 90% those patients who are fluid responders [14, 17]. On the other hand, a ΔDIVC of 12% was able to distinguish between volume responders and non-responders with a positive predictive value (PPV) of 93% and a negative predictive value (NPV) of 92% [52], but the combined sensitivity and specificity of dIVC diameter for predicting fluid responsiveness were 63% and 73%, respectively. [53].

Among spontaneously breathing patients, a dynamic assessment of the IVC is possible using the "collapsibility index" (cIVC) = [(Dmax—Dmin) / Dmax] × 100. A collapse greater than 40–50% is considered positive. This result has demonstrated its usefulness in correlating with right atrial pressure (RAP), but a clear cutoff point to differentiate volume responders has not yet been established in this group of patients [50]. Therefore, while the IVC is a parameter to consider regarding the identification of the shock aetiology and RAP, it is not suitable for distinguishing volume-responsive spontaneously breathing patients.

Assessment of volume tolerance.

Volume tolerance refers to the patient's ability to accept fluids without risk. Again, multi-organ ultrasound is essential, as it allows for the detection of previously unknown heart conditions or a pre-existing hypervolemic state.

## Role of lung ultrasound

Lung ultrasound is essential for the early detection of preclinical or clinical fluid overload and patients at risk of developing it. A-lines represent pleural reverberation and are visualized as hyper-echogenic, parallel, and equidistant lines. The presence of these lines with pleural sliding in a shock patient indicates volume tolerance, giving clinical confidence. B-lines, also called comet tails, are perpendicular to the pleural line. These lines are pathological and indicate an interstitial pattern, which may be due to extravascular lung water (EVLW) or prior interstitial involvement. Significant heart disease or elevated LV pressure supports the presence of heart failure, while patchy involvement with irregular pleura indicates Adult Respiratory Distress Syndrome (ARDS), interstitial pathology, or atypical pneumonia depending on the clinical context. EVLW can occur due to heart failure or ARDS because of changes in oncotic pressure from the inflammatory storm and disruption of the alveolocapillary barrier. A shock patient with B-lines signals to the clinician to be more cautious when administering fluid therapy, prioritizing vasoactive drugs, as EVLW has been shown to predict mortality and multiorgan failure [54]. EVLW measurement is performed with transpulmonary thermodilution as the gold standard. However, a correlation has been found with lung ultrasound measured in four quadrants, being superior to chest radiography [54, 55]. In fact, a correlation has been found between the number of B-lines and mortality [57] (represented in Online Resource 4).

## Assessment of elevated left ventricular pressure

When B-lines are present in the lung evaluation, distinguish between pulmonary distress and congestion as the main cause of B-lines can be challenging. In such cases, measuring pressures in the LV is useful. This is done using transmitral PW-Doppler. If the E/A ratio is greater than or equal to 2, the LV pressure is elevated. If it is lower or equal to 0.8 and the E wave is less than 50 cm/s there is normal pressure in LV. But if E/A ratio is between 0.8–2 or the E wave is greater than 50 cm/s regardless of E/A ratio, we will measure; E/e' ratio, TR velocity and left atrial volume to know LV pressure. The E/e' parameter by its own is directly related to LV filling pressure regardless of the rest of parameters. The LV pressure will be considered elevated if two of the following three criteria are met: E/e' greater than 14, TR velocity greater than 2.8 m/s, or left atrial volume greater than 34 ml/m$^2$ [58] (represented in Online Resource 5).

## Exploration of right systemic congestion

The impact of venous congestion on the liver and kidney can be quantified using PW-Doppler patterns of the suprahepatic, portal, and interlobular veins, through a congestion score called VExUS (Fig. 4) [59]. The presence of a dilated IVC without collapse should alert us, but most of the time, additional examinations are needed. Current studies related to shock involve intensive care patients, predominantly those with sepsis, which likely underestimates the actual prevalence of systemic congestion in this type of patient (due to low comorbidity). The prevalence is estimated at around 22% for VExUS 2–3 [60]. Venous congestion has been linked to renal failure. To date, neither the VExUS score parameters nor the pattern of the common femoral vein, have been shown to predict fluid response [60, 61]. However, it appears that patients whose VExUS score worsens in the early days of evolution develop adverse renal events [63]. Therefore, monitoring and prevention of venous congestion may be appropriate in shock evaluation.

## Role of ultrasound in tailoring of therapeutic effort

One of the most important aspects of being a clinician is the ability to adapt each treatment according to the characteristics, age, and prognosis of the patients. As internists or emergency physicians, we are confronted every day with elderly, pluripathological, and comorbid patients for whom active treatment and diagnostic tests do more harm than good. At this point, decisions are more difficult to make due to the lack of scientific support, as well as the beliefs and values of the physician and the patient's family. The role of ultrasound in the doctor-patient relationship appears clearly positive, providing the patient with reassurance, understanding, and trust in their doctors [64]. In these patients, POCUS allows the detection of unknown, advanced, or terminal diseases,

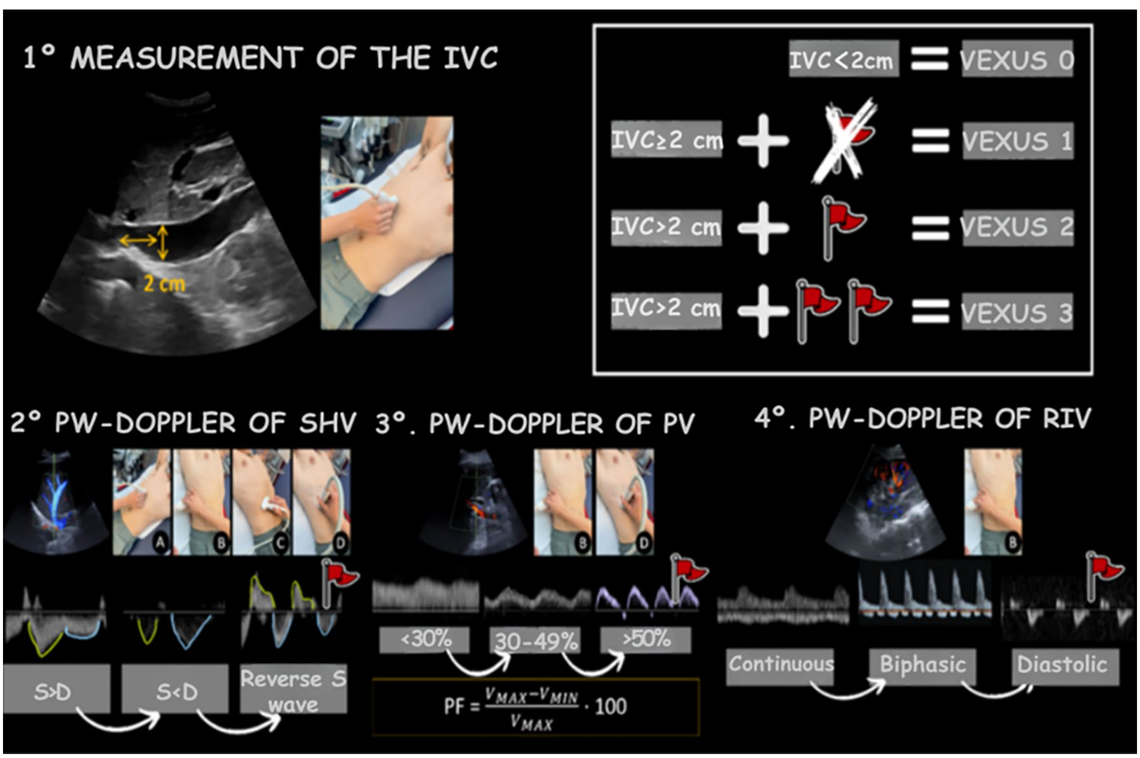


**Fig. 4** Assessment of venous congestion using the VExUS score. If the IVC is not dilated in the epigastric longitudinal plane, the VExUS is 0. If it is dilated, the suprahepatic veins (SHV), the portal vein (PV), and the intrarenal veins (RIV) are assessed using PW-Doppler. Red flags represent severe congestion patterns (reverse systolic (S) wave in SHV, pulsatility fraction (PF) in PV > 50%, and monophasic diastolic flow in RIV). The Score is calculated based on the number of red flags. Systemic venous assessment can be performed through multiple planes, but the right coronal is the only one that allows assessment of all three. **A** Epigastric longitudinal plane, **B** Right coronal plane, **C** Oblique subcostal plane, **D** Intercostal plane

as well as prognosis or lack of response to treatment. It also helps to take complicate decisions such as dismissing ICU admission, avoiding vasoactive drugs, or using only comfort measures also known as tailoring of therapeutic effort. In this context, the POCUS gives confidence to the medical team to adapt therapeutic measures to the clinical situation and brings peace of mind to the family.

## Conclusion

Shock is a prevalent condition among all patients and a complication of various diseases. It must be diagnosed promptly to treat and resuscitate patients. This is why ultrasound has acquired relevance in these patients as it is a non-invasive and bedside tool. Multi-organ ultrasound has proven its usefulness in the diagnosis, management, and monitoring of patients in shock, not only for ICU or ED patients but also for ward or home patients.

The use of POCUS in shock requires more physician expertise, but it is a powerful tool for assessing response to fluid therapy and detecting volume tolerance. In patients where invasive measures will not be performed, such as in internal medicine or the ED, POCUS may be the only alternative for shock management. However, further studies are needed to develop protocols and evaluate the prognostic implications of these tools.

In the meantime, our group recommends the assessments explained in this manuscript to provide the most comprehensive evaluation of patients with shock.

**Supplementary Information** The online version contains supplementary material available at https://doi.org/10.1007/s11739-025-03898-3.

**Acknowledgements** Our group thanks Dr. Tung Chen, and Dr. García de Casasola, for the opportunity to have participated in this project, and Dr. Torres Macho for the invitation.

**Funding** The group declares the absence of financial or non-financial interests that are directly or indirectly related to the work submitted for publication.

**Data availability** No specific datasets were generated or analyzed for this study, as it is a narrative review. All the information presented is based on previously published studies, which are referenced in the manuscript.

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