

Integrating structured point-of-care ultrasound into dengue fever management: A mini review and comprehensive clinical guide

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Abstract

Dengue fever is one of the most common mosquito-borne viral diseases and poses a significant health threat. The primary management involves hydration tailored to the disease stage and severity. Although many cases are mild, dengue can rapidly progress within hours. Complications such as plasma leakage and bleeding are difficult to detect through routine clinical assessment alone. In this context, point-of-care ultrasound (POCUS) has emerged as a valuable bedside tool for the early detection of fluid shifts and plasma leakage. Ultrasound findings in dengue-related plasma leakage include gallbladder wall thickening, ascites, pleural effusions, and other third-space fluid shifts. These sonographic signs often precede the clinical presentation of plasma leakage and can serve as early indicators for impending shock. Regular ultrasound assessment facilitates risk stratification and timely intervention, potentially reducing progression to dengue shock syndrome. Currently, there is no validated POCUS protocol specific to dengue assessment. We propose a standardized, structured ultrasound protocol focusing on key diagnostic parameters, coupled with serial serum hematocrit and lactate measurements for a comprehensive evaluation. This approach facilitates earlier identification of at-risk patients, thereby improving patient management, preventing clinical deterioration, and reducing morbidity and mortality associated with severe dengue.

Key Words: Dengue fever; Plasma leakage; Point-of-care ultrasound (POCUS); Pulmonary interstitial edema; Ascites; Pleural effusion; Pericardial effusion; Gallbladder wall thickening

Core Tip: This standardized, structured ultrasound protocol focuses on key diagnostic parameters, including gallbladder wall thickness; the presence and extent of ascites, pleural effusion and pericardial effusion; pulmonary interstitial edema; and assessment of fluid responsiveness/tolerance. When integrated with serial serum lactate measurements, it provides a comprehensive framework for clinical evaluation. This approach aims to enable earlier identification of at-risk patients across both general ward and intensive care settings, thereby improving patient care in dengue and reducing morbidity and mortality.

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INTRODUCTION

Dengue fever is one of the most common mosquito-borne viral diseases and poses a significant health threat. It is transmitted by *Aedes* mosquitoes, primarily *Aedes aegypti* and *Aedes albopictus*, which are commonly found in tropical and subtropical regions. Dengue fever is caused by the dengue virus, which has four distinct serotypes-namely DENV-1, DENV-2, DENV-3 and DENV-4[1]-each of which generates a unique host immune response. In 2013, a fifth serotype (DENV-5) was identified in Sarawak, Malaysia, which causes a milder form of disease[2]. Each episode of infection induces lifelong protective immunity to the homologous serotype but confers only partial and transient protection against other serotypes.

Dengue infection is a dynamic disease that manifests across a broad spectrum, ranging from asymptomatic infection to severe dengue. Diagnosis is primarily based on clinical history, supported by hematological and serological testing. According to the World Health Organisation (WHO) 2009 Dengue Classification, severe dengue is defined by the presence of any of the following clinical manifestations: (1) Severe plasma leakage leading to shock or fluid accumulation with respiratory distress; (2) Severe bleeding; and (3) Severe organ impairment, such as hepatitis (elevated transaminases ≥ 1000 IU/L), impaired consciousness, or cardiac involvement[3].

Clinically, dengue infection is divided into three phases (Figure 1), each characterized by distinct clinical manifestations and laboratory changes: Febrile phase, critical/defervescence phase and recovery phase. Febrile phase is marked by the onset of fever, which typically lasts 2-7 days. The other classical signs and symptoms include headache, retro-orbital pain, myalgia, arthralgia, and maculopapular rash. This is followed by the critical phase, which begins at defervescence and usually lasts 24-48 hours. It is usually characterized by decreasing platelet count and hemoconcentration, as shown in Figure 1. Severe dengue, as described earlier, often occurs during this phase due to plasma leakage or bleeding. Several indicators of plasma leakage that predict progression to severe dengue-such as pleural effusion, pericardial effusion, ascites, and gallbladder wall thickening-can be detected as early as day 3 of dengue infection, preceding the development of thrombocytopenia and hemoconcentration[3]. As plasma leakage subsides, patients enter into the recovery phase and begin to reabsorb extravasated fluids, which may result in transient systemic congestion.

To date, there is no specific antiviral therapy or vaccine that provides protection against all five DENV serotypes. Management is primarily supportive, with hydration carefully tailored to the stage and severity of the disease.

Although many cases are mild, dengue can progress rapidly within hours. The major cause of morbidity and mortality in dengue fever is plasma leakage. Indeed, the most feared complication of dengue - bleeding, arises from increased vascular permeability. However, both plasma leakage and bleeding are difficult to detect using routine clinical assessment alone. To date, the WHO has suggested that a rapid decline in platelet count accompanied with a rising hematocrit level can be used as a guide to determine the onset of plasma leakage[4]. Nevertheless, interpretation of hematocrit values may be confounded by situations such as concomitant bleeding, unknown baseline hematocrit level, accompanying gastrointestinal losses and hemodilution.

In this context, several studies have demonstrated that individual warning signs listed in the WHO guidelines have poor sensitivity and low positive predictive values for predicting severe disease[5,6]. Clinical examination and laboratory findings suggestive of severe dengue often lag behind ultrasonography findings[7]. Consequently, point-of-care ultrasound (POCUS) has emerged as a valuable bedside tool for clinicians in the evaluation and prognostication of patients with dengue[8,9], enabling early detection of fluid shifts and plasma leakage and guiding hydration therapy[10]. This advantage stems from the higher sensitivity of ultrasonography in detecting early pleural effusion, pericardial effusion and ascites. In conventional anteroposterior chest radiography, pleural effusion is typically detectable only when fluid volume exceeds approximately 200 mL, whereas point-of-care ultrasonography can identify as little as 5-50 mL of fluid with near 100% sensitivity[11]. In addition, ultrasonography avoids exposure to ionizing radiation[12], an advantage that is particularly relevant in settings where laboratory results may not be available in a timely manner.

Currently, there is no validated POCUS protocol specific to dengue assessment. This review focuses on the POCUS techniques and sonographic findings relevant to the different phases of dengue infection.

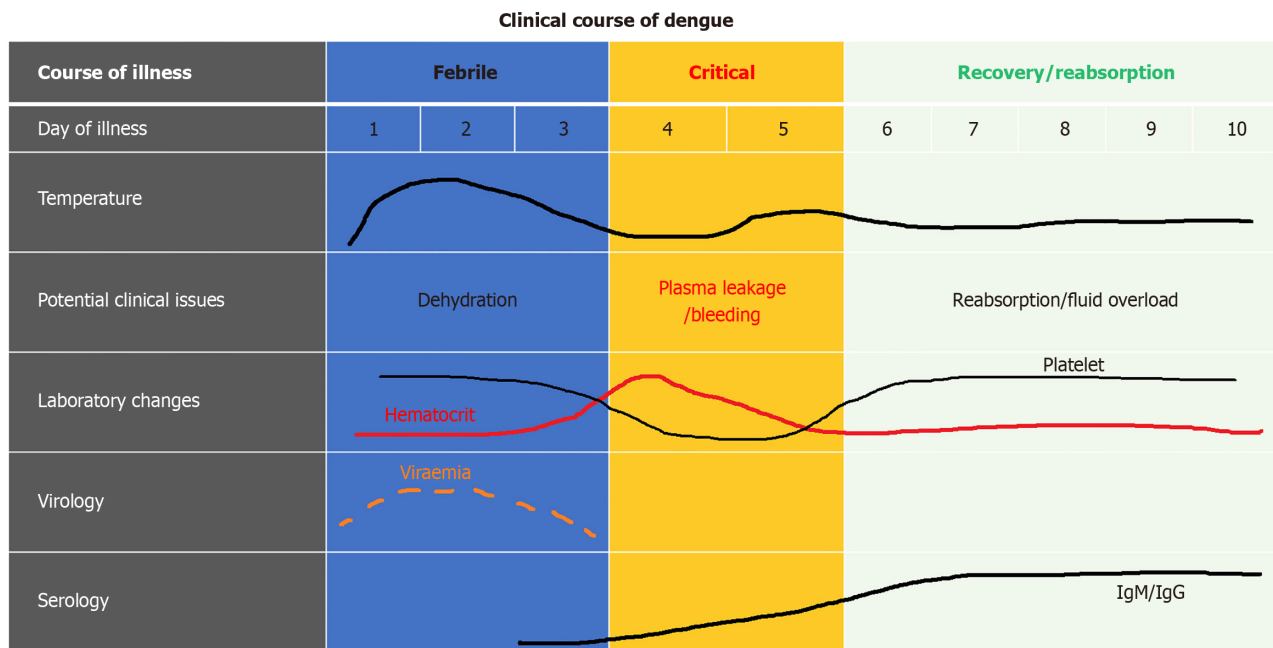


Figure 1 Three phases of dengue fever. Dengue fever begins with febrile phase after an incubation period of 4 to 7 days. This is followed by critical phase which is characterised by thrombocytopenia and hemoconcentration. Severe dengue usually sets in during this phase. Recovery phase usually starts during day 6 to 8 of the illness. (Adapted from Malaysia CPG Management of Dengue Infection in Adults 2015).

DENGUE ASSESSMENT POCUS PROTOCOL

Ultrasonographic evidence of pleural effusion, pulmonary interstitial edema, ascites, pericholecystic fluid, and gallbladder wall thickening is highly suggestive of plasma leakage, particularly during the critical phase of dengue infection. Besides that, POCUS plays an important role in identifying both fluid responsiveness and fluid intolerance. Assessment of fluid responsiveness has long been advocated in fluid management to determine whether further fluid resuscitation will lead to improvement in cardiac output and organ perfusion; whereas the concept of fluid intolerance has gained increasing attention, as venous congestion with subsequent impairment of end-organ perfusion is associated with poorer clinical outcomes among critically ill patients, especially those with severe dengue. Therefore, integrating the concepts of both fluid responsiveness and fluid tolerance should be considered the standard of care for optimizing individualized fluid management[13]. In the subsequent section, we will emphasize the technical aspects and interpretation of the relevant ultrasonographic features.

TECHNICAL ASPECTS

This dengue assessment POCUS protocol focuses on two major components: Detection of plasma leakage and assessment of fluid responsiveness and tolerance. It comprises five key steps, with steps 1 to 3 focusing on identifying signs of plasma leakage, while steps 4 and 5 emphasize detailed assessment of fluid responsiveness and fluid intolerance (Figure 2).

Signs of plasma leakage

Step 1: Lung scan for pulmonary interstitial edema in dengue fever: Lung ultrasound findings are based on the principle of acoustic impedance[14,15], which reflects the resistance of particles within a medium to mechanical vibrations. Acoustic impedance increases in proportion to both the density of the medium and the velocity of ultrasound propagation within it. Air has a very low acoustic impedance; therefore, when ultrasound traverses from soft tissue to air, the large acoustic impedance mismatch results in 99% of the ultrasound being reflected. This produces reverberation artifacts that appear as a series of equally spaced horizontal lines, known as A-lines (Figure 3A), which are characteristics of normally aerated lungs.

In dengue, abnormal lung ultrasound findings of interest include interstitial edema and pleural effusion[16]. The presence of these findings is indicative of plasma leakage.

In this protocol, step 1 is performed using a curvilinear probe (2-5 MHz), placed sequentially at the L1, L2, R1, and R2 regions, as illustrated in Figure 2. An increase in the density of the underlying lung, caused by displacement of air by transudate and exudate - as occurs during plasma leakage and bleeding in the critical phase of dengue fever - reduces the acoustic impedance mismatch between the pleura and the underlying lung structures. These alterations create an acoustic trap, resulting in repeated back-and-forth reflection of the ultrasound beam between the lung and the transducer, thereby producing characteristic comet-tail artifacts (Figure 3B)[17,18]. B-lines, also known as ultrasound lung comets, are discrete vertical reverberation artifacts that originate from the pleural line, extending to the bottom of the image without loss of

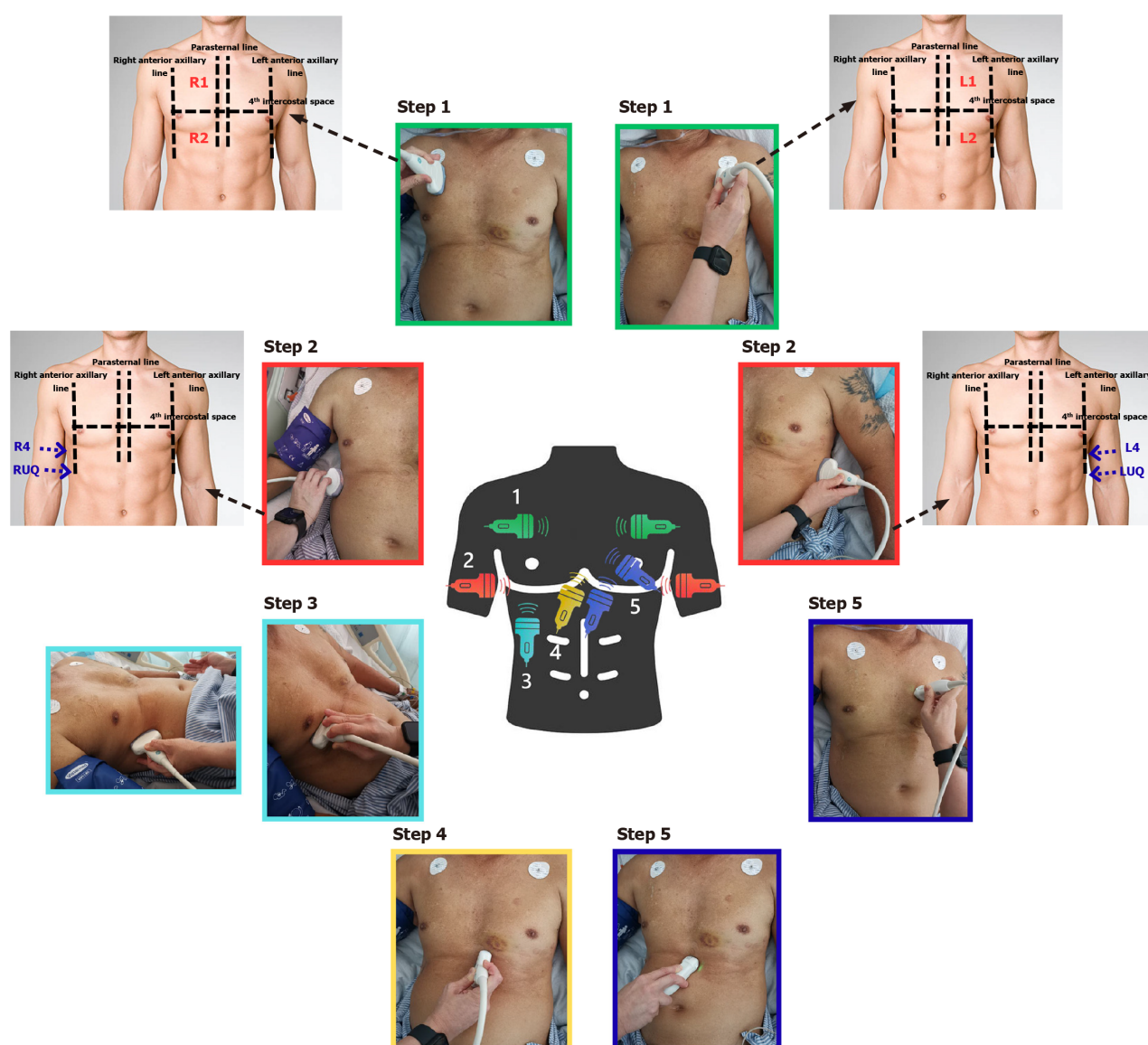


Figure 2 Overview of dengue assessment point-of-care ultrasound (POCUS) protocol. Probe choice and placement are illustrated. Steps 1-3 for identifying signs of plasma leakage; steps 4-5 for assessment of fluid responsiveness and fluid intolerance. RUQ: Right upper quadrant; LUQ: Left upper quadrant.

intensity, and move synchronously with lung sliding. A defining feature of B-lines is their ability to obscure A-lines. Plasma leakage into the pulmonary interstitium during critical phase may manifest as B-lines on lung ultrasound[19]. This B-line reverberation artifact can be graded objectively using lung ultrasound score (LUS) which comprises of score 0, 1, 2, and 3[20,21]. Figure 4 illustrates the detailed criteria for LUS grading.

Step 2: Identification of free fluid in the left and right upper quadrants (R4, right upper quadrant, L4, left upper quadrant regions) in dengue fever: Step 2 involves identification of free fluid in pleural cavities (R4 and L4); tip of the liver, perihepatic region and hepatorenal space in the right upper quadrant (RUQ); perisplenic and splenorenal space in the left upper quadrant (LUQ); and perinephric region, using a curvilinear probe (3-5 MHz) as illustrated in Figure 2. The liver and spleen provide excellent acoustic windows for the detection of pleural effusion. Pleural effusion appears as a dark or anechoic collection in the costophrenic recess above the diaphragm (Figure 5A) or near the chest wall, with appearance of “quad sign” (Figure 5B). The quad sign refers to the typical boundaries defining a pleural effusion, with the vertical boundaries formed by the two anechoic posterior rib shadows and the horizontal boundaries defined by the parietal pleura and the visceral pleura, with the latter being indistinguishable from the adjacent parenchyma, commonly referred to as the “lung line”[22]. Similarly, the presence of “spine sign” (Figure 5A) and “sinusoid sign” serves as indirect indicators of pleural effusion[23]. Under normal conditions, the spine does not extend beyond the diaphragm on ultrasonography because the lung “curtains” over it during expiration. However, the presence of fluid in the pleural space results in posterior acoustic enhancement, leading to the appearance of “spine sign” above the diaphragm[24,25]. Conversely, the presence of “curtain sign” together with a mirror artifact (Figure 6) allows the clinician to confidently exclude pleural effusion[26].

The next focus in step 2 will be identification of free fluid in RUQ and LUQ. Clinical detection of plasma leakage through physical examination for ascites is challenging as a substantial volume of fluid must accumulate before reliable

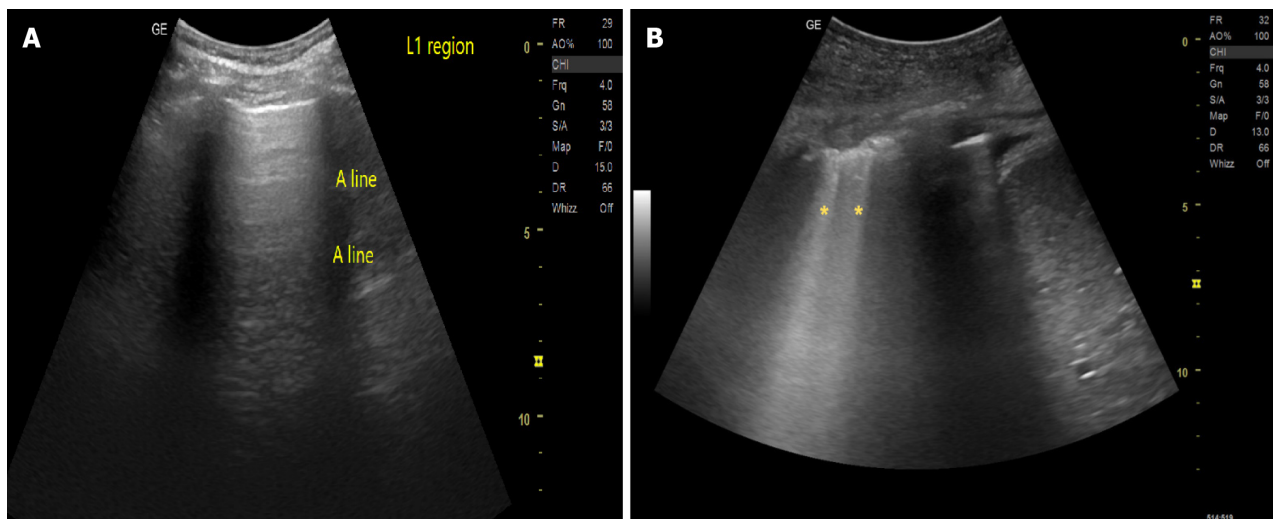


Figure 3 Lung ultrasound. A: A-lines as a result of reverberation in normal aerated lung. It appears as a series of equally spaced horizontal lines; B: B-lines (yellow asterisks) due to discrete reverberation causing characteristic vertical comet-tail artifacts from interstitial edema.

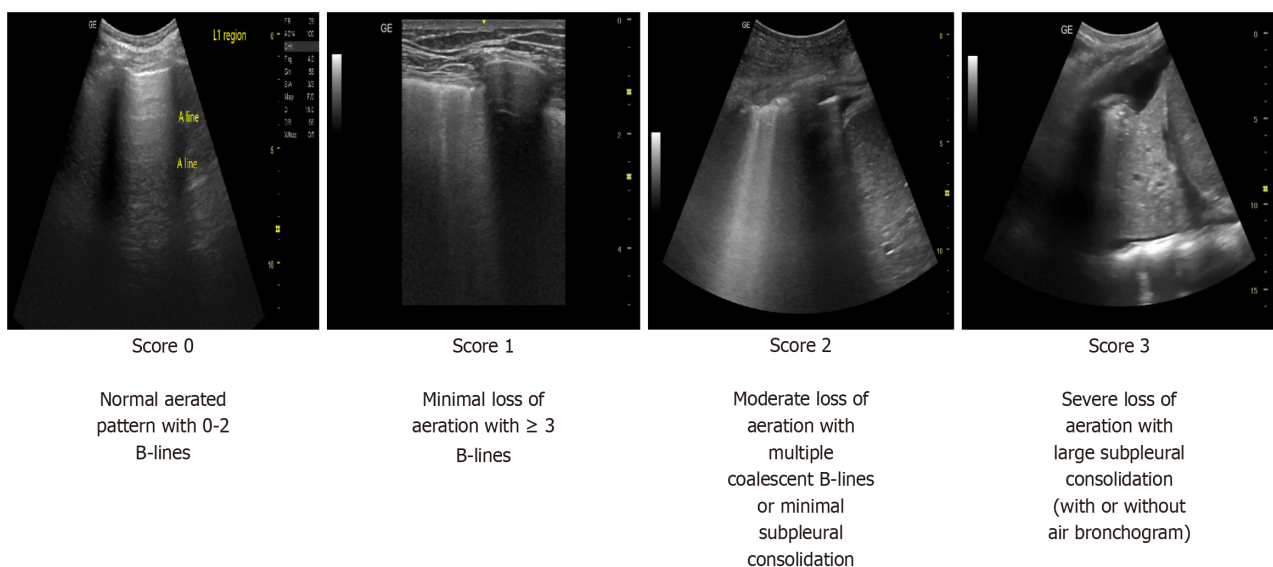


Figure 4 Lung ultrasound score. Lung ultrasound score (LUS) ranging from 0 to 3 for each lung quadrant (R1-R4 and L1-L4). An LUS of 1 or 2 across the L1, L2, R1 and R2 regions may be suggestive of pulmonary interstitial edema in dengue fever, reflecting ongoing plasma leakage.

detection is possible. On ultrasonography, ascites appears as a dark or anechoic space, bounded superficially by the abdominal wall and by the bright or hyperechoic peritoneum[27]. Ascites typically accumulates first in the dependant portions of the abdominal cavity, particularly the hepatorenal or splenorenal pouch and the pelvic cavity (Figure 7). When assessing for fluid accumulation, particular attention should be directed to the tip of the liver, as this is often the earliest site where even minimal amounts of fluid become detectable. Other abdominal ultrasonographic features associated with severe dengue include perinephric fluid, hepatomegaly and splenomegaly[28,29].

Step 3: Gallbladder assessment in dengue fever: A curvilinear probe (3-5 MHz) is placed horizontally in the right subcostal region or along the right anterior axillary line, as illustrated in step 3 of Figure 2. Gallbladder wall thickening with associated pericholecystic fluid is a sensitive ultrasonographic finding of severe dengue[30]. The anterior gallbladder wall is used for measurement of the gallbladder wall thickness (GBWT) (Figure 8A)[31]. This is because bile, being liquid in nature, produces posterior acoustic enhancement, which may cause the posterior wall to appear falsely thickened. Various GBWT cutoff values have been proposed, with 3 mm being the most commonly used threshold in a large number of studies[8]. Four distinct patterns of gallbladder wall thickening have been described: Uniform echogenic pattern, striated or tram track pattern, asymmetric pattern and honeycombing pattern[30]. Gallbladder wall thickening (Figure 8B) often precedes the detection of ascites or pleural effusion by 1-3 days[32], with clinical improvement typically coinciding with resolution of the gallbladder wall thickening[28]. Accordingly, ultrasound-detected gallbladder wall thickening and its associated patterns have been suggested as potential indicators of disease severity[33-35].

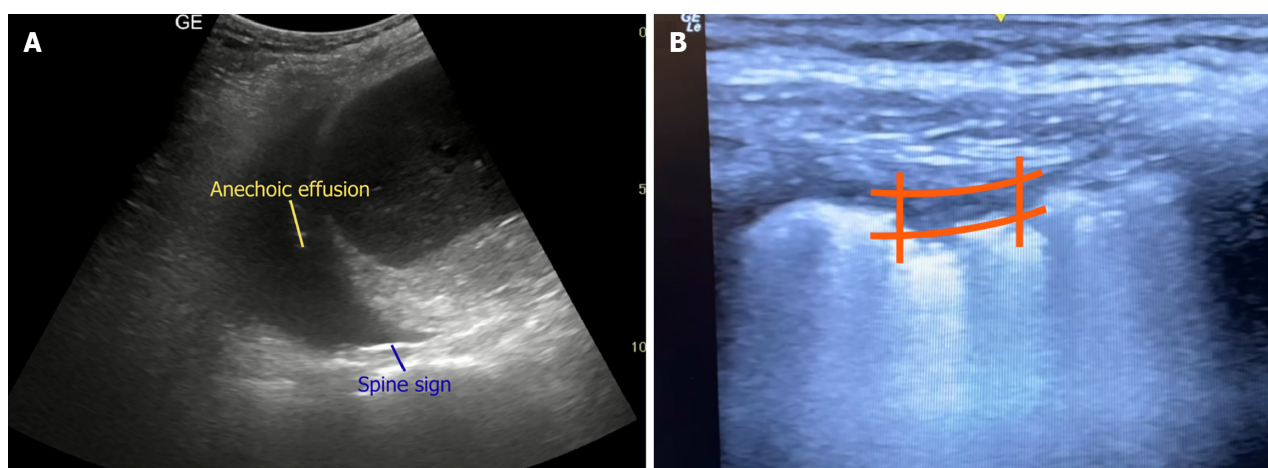


Figure 5 Ultrasonographic features of pleural effusion. A: Pleural effusion manifests as anechoic collection above the diaphragm with presence of spine sign at R4 region; B: Quad sign suggestive of pleural effusion (R4 region). The orange lines mark the borders of the quad sign - vertical borders by the rib shadows and horizontal borders by parietal and visceral pleura respectively.

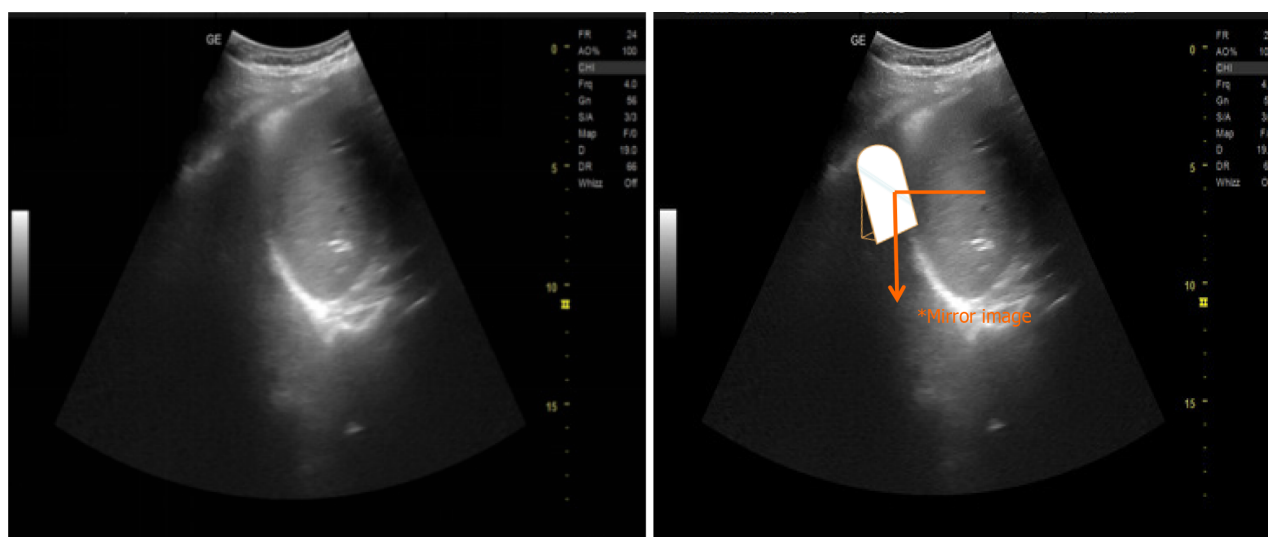


Figure 6 Mirror artifact. The presence of mirror image artifact rules out pleural effusion. Orange asterisk denotes the mirror image of liver.

Ultrasonographic features of fluid responsiveness and fluid intolerance

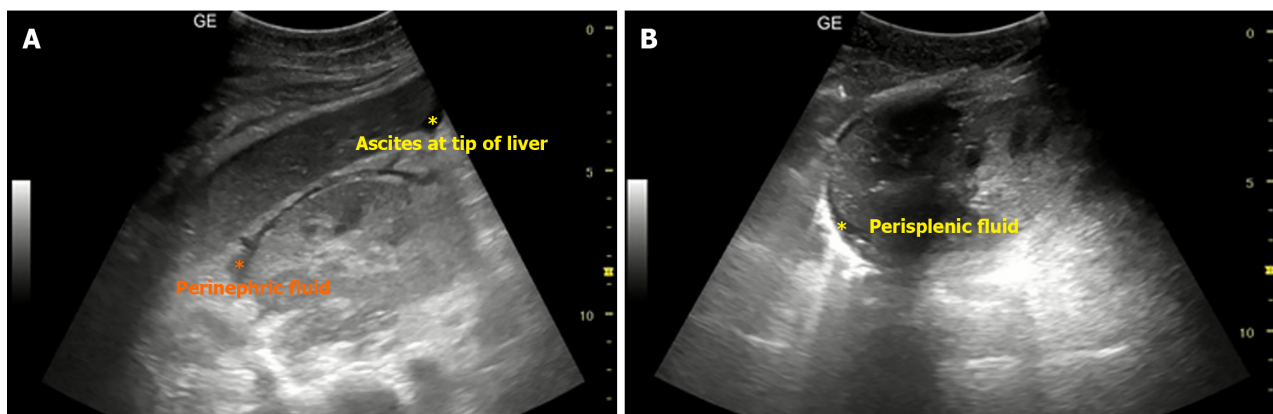
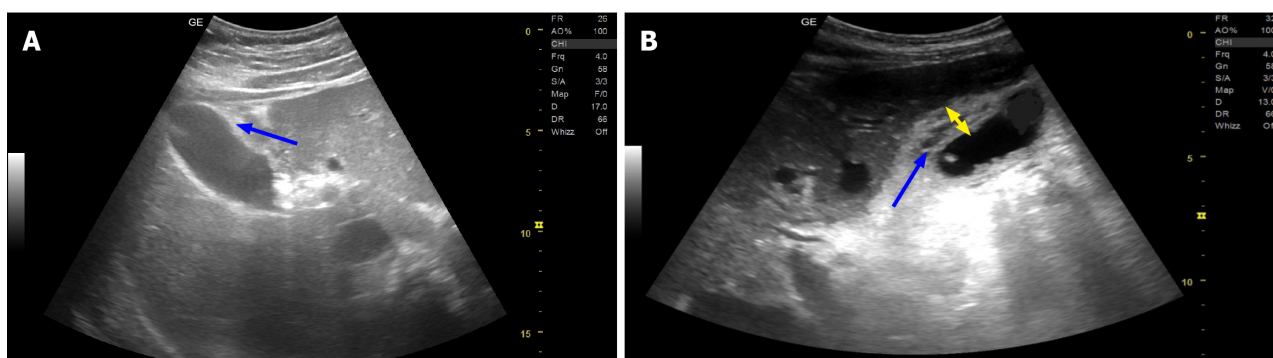
Step 4: Inferior vena cava assessment in dengue fever: The inferior vena cava (IVC) is identified using either a curvilinear (2-5 MHz) or phased array probe (3-8 MHz), placed in the subcostal region, or in the right lateral subcostal region at the mid-axillary line in cases of challenging body habitus (Figure 2). The optimal location for IVC size measurement is 3-5 cm from the inferior cavoatrial junction or 1 cm from the junction where the hepatic vein drains into the IVC. The anteroposterior internal diameter measurement is measured either in the longitudinal or transverse axis during inspiration and expiration (Figures 9 and 10) using either B-mode or M-mode imaging[36]. IVC diameter and collapsibility (caval index) have traditionally been identified as non-invasive surrogates for central venous pressure or right atrial pressure (RAP) and to guide fluid responsiveness[37,38]. An IVC diameter ≤ 2.1 cm and collapsibility $> 50\%$ during inspiration suggest a RAP of 0-5 mmHg, whereas a diameter > 2.1 cm with $< 50\%$ inspiratory collapse indicates a high RAP of 10-20 mmHg. If both the IVC diameter and caval index do not follow these patterns, a mean RAP value of 8 mmHg (range 5-10 mmHg) may be assumed (Table 1). In mechanically ventilated patient, the distensibility index, calculated as (maximum diameter on inspiration - minimum diameter on expiration)/minimum diameter on expiration, is utilized instead[39,40]. Generally, IVC ≤ 2.1 cm with caval index more than 50% (non mechanically ventilated) or distensibility index more than 18% (mechanically ventilated) indicates fluid responsiveness. Conversely, a prominent IVC with diameter > 2.1 cm with a caval index less than 50% or a distensibility index less than 18% may indicate elevated RAP, suggesting fluid intolerance.

Step 5: Cardiac assessment in dengue fever: In step 5, echocardiography is performed using a phased-array probe (3-8 MHz). Two major views are utilized: The parasternal views (long and short axis) and the subcostal four-chamber view (Figure 2). Echocardiography can guide clinicians in fluid resuscitation of patients with dengue fever by assessing fluid

Table 1 Correlation of inferior vena cava diameter and caval/distensibility indices with right atrial pressure, fluid responsiveness and fluid intolerance

IVC diameter (cm)	IVC inspiratory collapsibility or distensibility (%)	Right atrial pressure (mmHg)	Fluid responsiveness (to correlate with other features)	Fluid intolerance (to correlate with other features)
> 2.1	Collapsibility < 50 Distensibility < 18	10-20	No	Possible
> 2.1	Collapsibility > 50 Distensibility > 18	5-10	Possible (judicious fluid);	Possible
≤ 2.1	Collapsibility < 50 Distensibility < 18	5-10	Possible (judicious fluid)	Possible
≤ 2.1	Collapsibility > 50 Distensibility > 18	0-5	Yes	Unlikely

IVC: Inferior vena cava.

**Figure 7 Ultrasonographic features of free fluid in abdomen.** A: Free fluid at hepatorenal pouch and perinephric fluid in dengue, suggestive of plasma leakage. Attention should be directed to the tip of the liver, as this is often the earliest site where fluid becomes detectable; B: Perisplenic fluid in dengue, suggestive of plasma leakage.**Figure 8 Gallbladder wall.** A: Anterior gallbladder wall (blue arrow) is used to measure the gallbladder wall thickness; B: Gallbladder wall thickening (yellow double arrowhead) with honeycombing pattern (blue arrow) in a severe dengue patient. Other patterns of gallbladder wall thickening include uniform echogenic pattern, striated or tram track pattern and asymmetric pattern.

tolerance. The “4 D’s” concept plays a pivotal role in optimizing fluid management in critically ill patients[41]. The four components include: Drugs (choice of fluid), dosing (amount of fluid), duration (rate of fluid administration) and de-escalation (stepwise reduction of fluid therapy). Assessment of left ventricular systolic function provides essential information to guide the dosing and duration components of the 4 D’s framework. Several echocardiographic methods

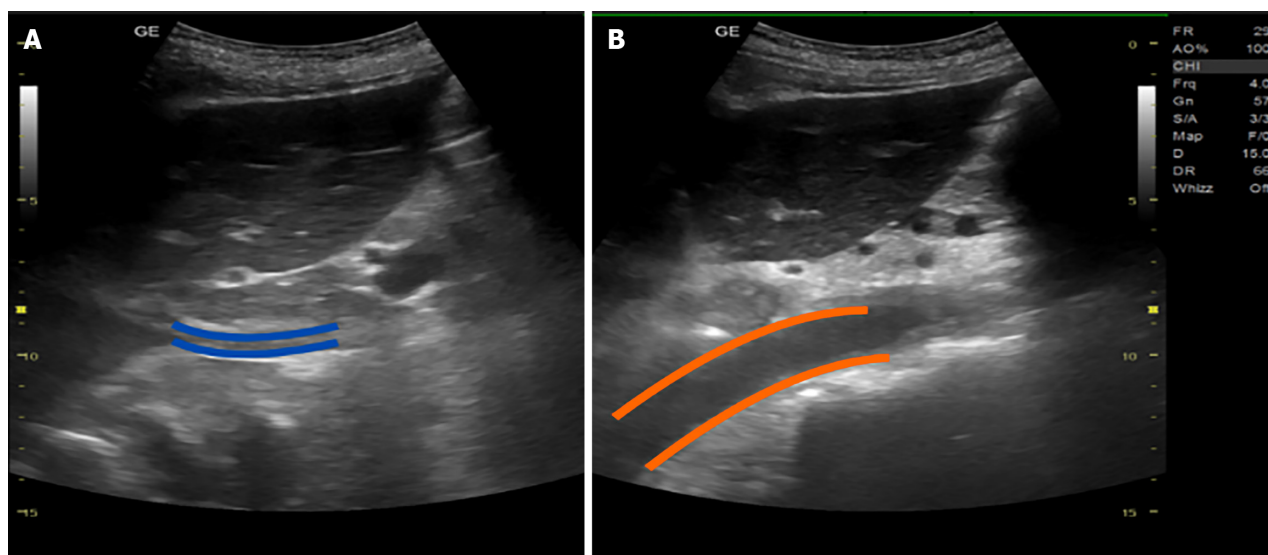


Figure 9 Inferior vena cava (blue marking) and abdominal aorta (orange marking) (longitudinal view). Note that aorta has a thicker vessel wall and it is more medially located than inferior vena cava (IVC). Blue marking indicates IVC while orange marking indicates abdominal aorta.

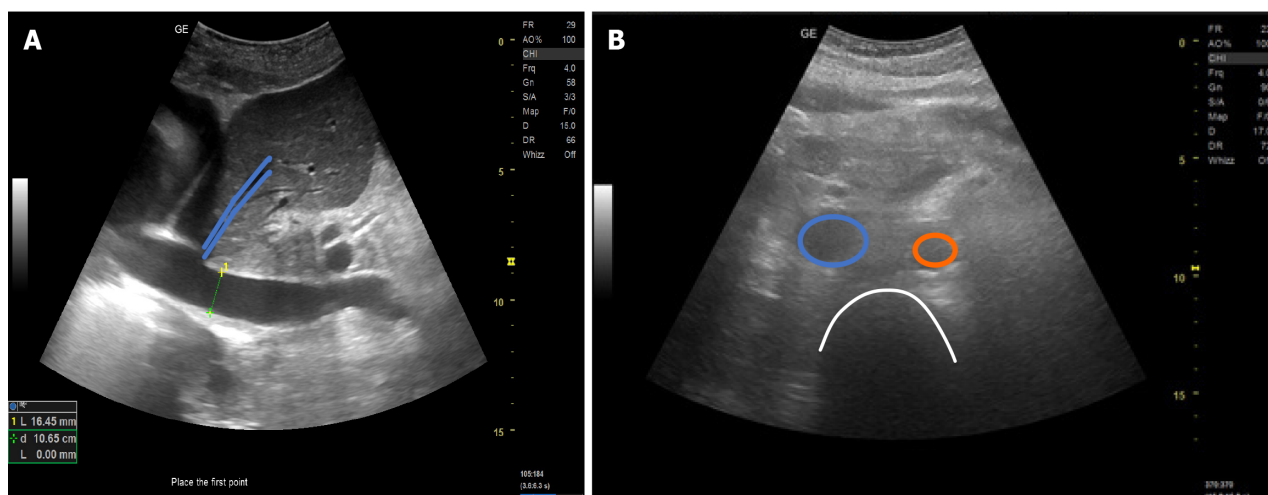


Figure 10 Inferior vena cava. A: Longitudinal view. Blue marking annotates hepatic vein. Measurement of inferior vena cava (IVC) diameter at 3–5 cm away from the inferior cavoatrial junction or 1 cm away from hepatic vein-IVC junction; B: Transverse view. Blue marking annotates inferior vena cava; orange marking annotates abdominal aorta; white marking annotates thoracic spine.

may be used to evaluate left ventricular systolic function, including visual estimation “eyeballing”, fractional shortening, mitral valve E-point septal separation (EPSS), mitral annular plane systolic excursion (MAPSE) using M-mode, and the Teicholz and Simpson methods derived from two-dimensional echocardiography (Figure 11)[42,43]. In addition, cardiac assessment may aid in the identification of dengue-related cardiomyopathy[44].

This step also includes evaluation for pericardial effusion (Figure 12), which may signify plasma leakage in severe dengue[5].

Table 2 summarizes the key potential clinical issues and their corresponding ultrasonographic findings across the different phases of dengue fever.

CLINICAL APPLICATIONS OF DENGUE ASSESSMENT POCUS PROTOCOL

This POCUS protocol aims to support risk stratification and guide individualized hydration in dengue fever according to illness severity. Optimal fluid management requires adjustment of hydration volumes based on both the stage and severity of disease[45]. When combined with serum hematocrit and lactate measurements, ultrasonographic findings allow for more precise fluid titration, thereby reducing the risks of both under- and over-hydration compared with reliance on clinical assessment alone[32,46].

Table 2 Summary of potential issues during each phase of dengue fever and their relevant point-of-care ultrasound (POCUS) findings

Phase of disease	Potential issues	Expected finding(s)	POCUS characteristics
Febrile phase	Dehydration (normal-mildly raised serum lactate)	No signs of plasma leakage	Step 1: A-profile
			Step 2: Absence of free fluid
			Step 3: Normal GBWT
		Small IVC diameter	Step 4: Small IVC with > 50% collapsibility
		Underfilled ventricles	Step 5: Underfilled left ventricle
Critical phase	Plasma leakage (raised hematocrit and raised serum lactate)	Pulmonary interstitial edema	Step 1: B-profile
		Pleural effusion	Step 2: Presence of pleural effusion
		Free fluid in abdomen	Step 2: Presence of ascites
		Gallbladder wall thickening with pericholecystic fluid	Step 3: Gallbladder wall thickening (> 3 mm)
		Small IVC diameter	Step 4: Small IVC with > 50% collapsibility
	Bleeding (reducing hematocrit with raised serum lactate)	Pericardial effusion or myocardial dysfunction	Step 5: Presence of pericardial effusion or depressed left ventricular ejection fraction
		Normal or pulmonary interstitial edema	Step 1: A-profile or B-profile
		Free fluid in abdomen or normal finding	Step 2: Presence of ascites
		Gallbladder wall thickening with pericholecystic fluid or normal gallbladder	Step 3: Gallbladder wall thickening (> 3 mm)
		Normal or small IVC diameter	Step 4: Small IVC with > 50% collapsibility
Recovery phase	Dengue cardiomyopathy	Myocardial dysfunction	Step 5: Depressed left ventricular ejection fraction
		Reabsorption (systemic congestion with improving serum lactate)	Step 1: B-profile
		Pulmonary interstitial edema	Step 2: Presence of pleural effusion
		Pleural effusion	Step 2: Presence of ascites
		Free fluid in abdomen	Step 2: Presence of ascites
		Resolution of gallbladder wall thickening	Step 3: Resolution of gallbladder wall thickening
		Prominent IVC diameter	Step 4: Prominent IVC (> 2.1 cm) with < 50% collapsibility

Point-of-care ultrasound (POCUS) characteristics across different phases of dengue: Based on dengue POCUS protocol illustrated in [Figure 2](#). GBWT: Gallbladder wall thickness; IVC: Inferior vena cava; POCUS: Point-of-care ultrasound.

This dengue assessment POCUS protocol provides a standardized approach for managing patients across all phases of the illness and enables early identification of individuals at risk of severe dengue.

A key clinical application of this protocol is the evaluation of patients who present with hypotension despite initial fluid resuscitation[47]. In such situations, the differential diagnoses include: (1) Hypovolemic shock due to dehydration secondary to reduced oral intake; (2) Decompensated shock in severe dengue resulting from plasma leakage or haemorrhage; (3) Cardiogenic shock attributable to dengue-related cardiomyopathy or underlying heart failure; (4) Septic shock due to a superimposed bacterial infection; and (5) Less commonly, obstructive shock arising from complications such as pulmonary embolism.

In this scenario, when used alongside routine laboratory investigations (including white blood cell and platelet trends, hematocrit levels) and serial lactate monitoring, this POCUS protocol enhances diagnostic accuracy and facilitates timely, goal-directed resuscitation[32].

For instance, if the IVC is small in calibre (step 4) in the absence of ultrasonographic features of plasma leakage (steps 1-3), and this is accompanied by clinical signs of dehydration, a normal or mildly elevated hematocrit, and normal serum lactate, the findings are most consistent with hypovolemia. In such cases, the appropriate management strategy is fluid repletion to restore intravascular volume, typically using crystalloids at rates of up to 5 mL/kg/hour[45,48,49]. Serial POCUS assessments are essential for evaluating therapeutic response and optimizing both the rate and volume of fluid administration, as discussed previously.

Conversely, if the IVC remains small in calibre (step 4) but is accompanied by ultrasonographic evidence of plasma leakage (steps 1-3) such as pulmonary interstitial edema with B-lines on lung ultrasound, intra-abdominal free fluid, and gallbladder wall thickening or edema, together with elevated serum lactate, the clinical picture is more suggestive of significant plasma leakage or bleeding. Differentiating plasma leakage from bleeding can be challenging; however,

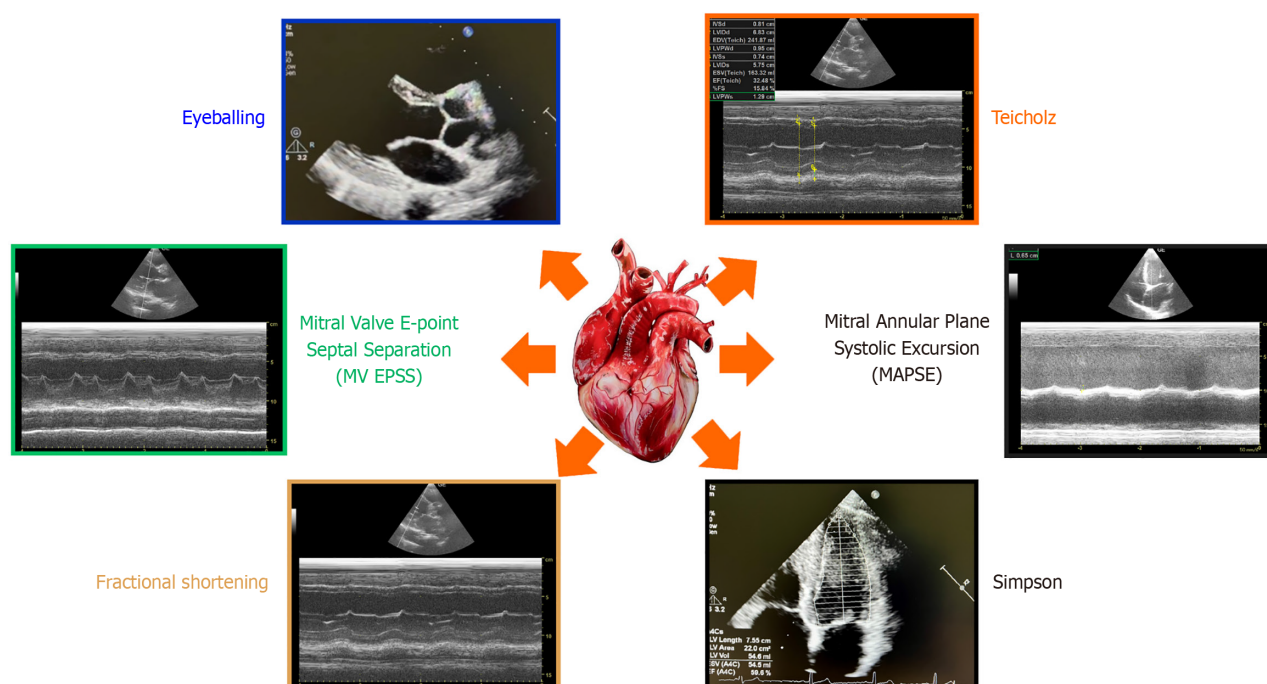


Figure 11 Different methods of left ventricular ejection fraction assessment.

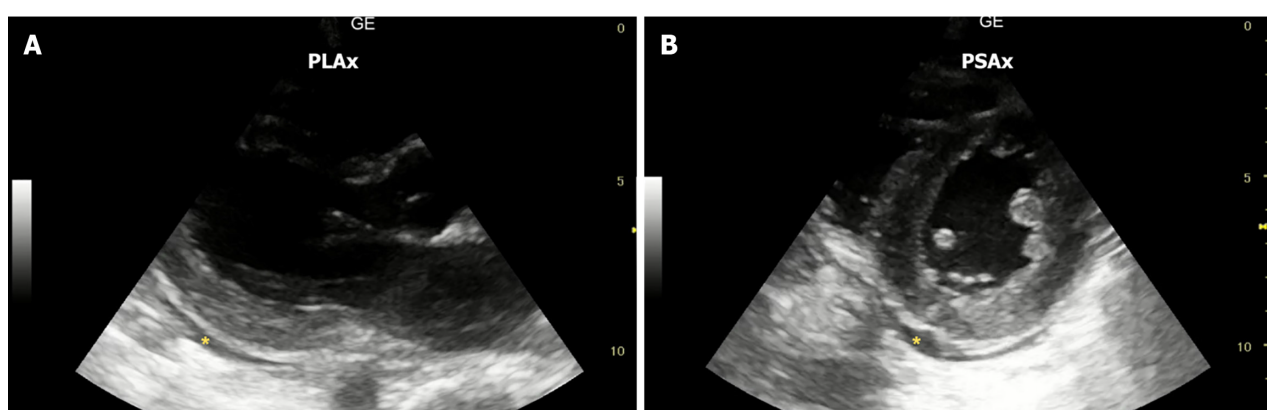


Figure 12 Pericardial effusion (yellow asterisks) due to plasma leakage. A: Parasternal long axis view; B: Parasternal short axis view. PLAx: Parasternal long axis; PSAx: Parasternal short axis.

integration of blood parameters with POCUS findings substantially improves clinical decision-making. In severe plasma leakage, both serum lactate and hematocrit typically rise despite initial fluid resuscitation, along with ultrasonographic evidence of leakage (steps 1-3). Furthermore, these sonographic signs often precede overt clinical manifestations, serving as early indicators of impending shock[28-30,32,33]. In contrast, in occult bleeding, serum lactate is elevated while hematocrit is disproportionately low relative to the degree of shock expected from plasma leakage alone. Management therefore differs accordingly: Severe plasma leakage requires aggressive fluid resuscitation (up to 20 mL /kg/hour) with crystalloids or colloids is indicated[45,48,49], whereas haemorrhage necessitates transfusion of blood or blood products [45,50].

POCUS is also valuable in differentiating dengue-related cardiomyopathy or myocarditis from plasma leakage, as management strategies differ substantially. Both conditions may present with pulmonary interstitial edema (B-profile on lung ultrasound), intraperitoneal free fluid, and gallbladder wall edema. Assessment of the IVC and focused echocardiography (steps 4-5) is critical in these scenarios[51,52]. In dengue cardiomyopathy, the IVC is typically plethoric (large calibre), and left ventricular systolic function may be impaired, distinguishing cardiogenic from distributive or hypovolemic shock. In cases of fluid overload secondary to dengue cardiomyopathy, a judicious decongestion strategy may be required, guided by advanced POCUS techniques such as the venous excess ultrasound (VExUS) score (Figure 13) [53-55]. By contrast, aggressive fluid resuscitation, particularly guided by POCUS, remains crucial in plasma leakage, including in patients with pre-existing cardiac or renal dysfunction[50].

Given the heterogeneity and evolving complexity of dengue manifestations, patients - particularly those with multiple comorbidities - may develop a wide range of complications or overlapping pathological processes, including concurrent

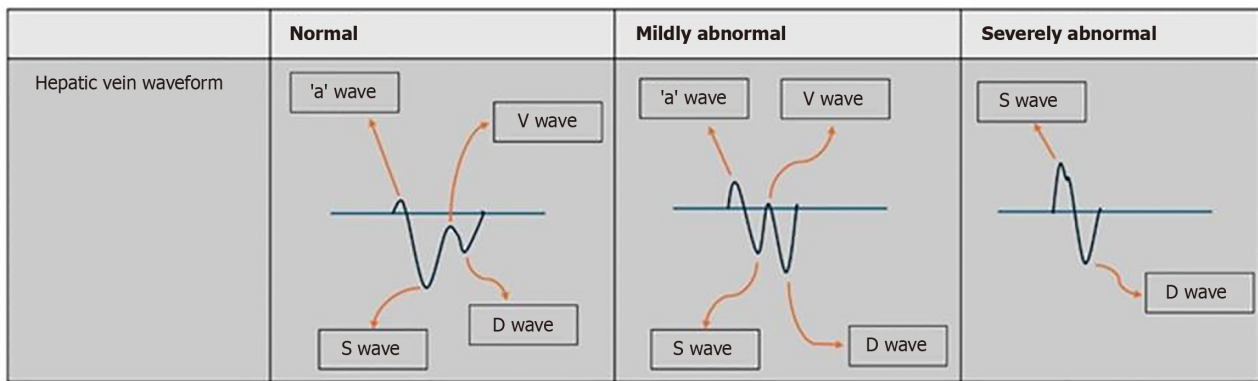
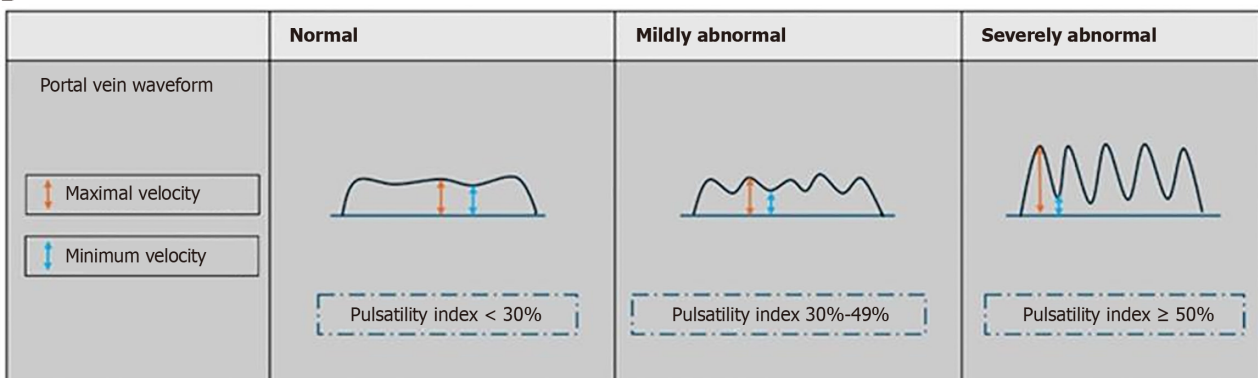
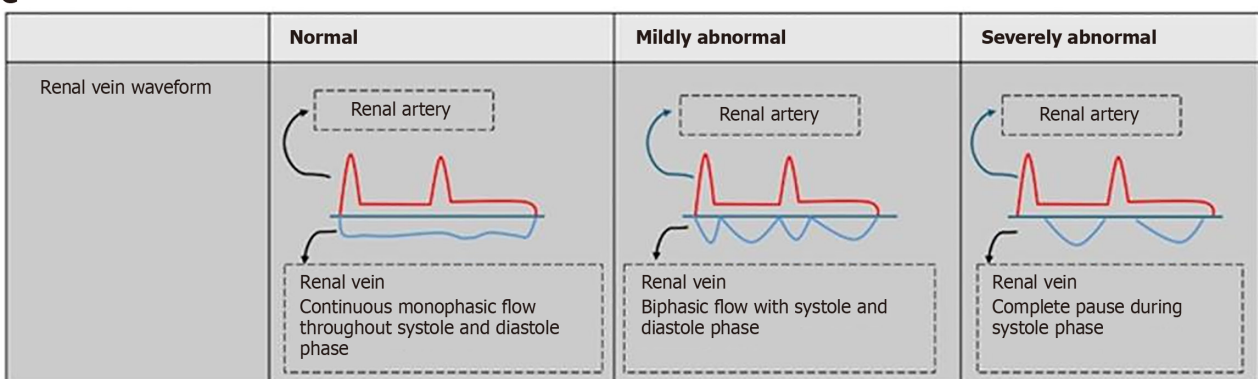
A**B****C**

Figure 13 Venous excess ultrasound (VExUS) scoring - non-invasive measurements to evaluate and score the severity of venous congestion. It involves assessing the inferior vena cava, hepatic vein, portal vein and renal vein waveforms. A: Hepatic vein waveforms; B: Portal vein waveforms; C: Renal vein waveforms. Adapted from: Chin WV, Ngai MMI, See KC. Venous excess ultrasound: A mini-review and practical guide for its application in critically ill patients. *World J Crit Care Med* 2025; 14: 101708

plasma leakage and dengue-related cardiomyopathy. Therefore, reliance on a single POCUS parameter or a “one-size-fits-all” strategy is neither appropriate nor clinically meaningful. Management should instead be guided by an integrated assessment incorporating physical examination, dynamic laboratory trends, POCUS findings and astute clinical judgment.

In summary, this POCUS protocol is intended to complement, not replacing comprehensive clinical assessment, thereby supporting informed decision-making in complex clinical presentations.

Table 3 summarises common clinical scenarios in dengue fever, their associated laboratory and ultrasonographical findings and corresponding management strategies[45].

LIMITATION OF DENGUE ASSESSMENT POCUS PROTOCOL

Although the dengue assessment POCUS protocol is valuable in assisting clinicians with prognostication and management of dengue, it is not without limitations. Effective implementation necessitates proficiency in both ultrasound

Table 3 Common clinical scenarios in dengue fever and corresponding management strategies

Issues	Lung scan (step 1)	Free fluid (step 2)	Gallbladder (step 3)	IVC (step 4)	ECHO (step 5)	Hematocrit	Lactate	Management options (according to local guidelines)
Dehydration	Normal	No	Normal	< 2.1 cm Collapsibility > 50%	Normal	Normal or raised	Normal	Hydration (0.5-5 mL/kg/hour)
Plasma leakage (early)	Normal	Yes	Thickened	< 2.1 cm Collapsibility > 50%	Normal	Raised	Normal	Hydration (5-20 mL/kg/hour)
Plasma leakage (late)	Interstitial edema	Yes	Thickened	< 2.1 cm Collapsibility > 50%	Pericardial effusion	Raised	Raised	Hydration (5-20 mL/kg/hour)
Bleeding	Normal or interstitial edema	Yes	Normal or thickened	< 2.1cm Collapsibility varies	Normal	Reducing	Raised	Blood product transfusion
Reabsorption with systemic congestion	Interstitial edema	Yes	Normal or thickened	≥ 2.1cm Collapsibility < 50%	Normal	Varies	Normal	Stop hydration (consider diuresis)
Dengue cardiomyopathy/ myocarditis	Interstitial edema	Yes	Normal or thickened	≥ 2.1cm Collapsibility < 50%	Reduced LVEF	Varies	Varies	Judicious hydration
Preexisting heart failure or renal failure	Interstitial edema	Varies	Varies	≥ 2.1cm Collapsibility varies	Reduced LVEF	Varies	Varies	Judicious hydration (consider diuresis)
Preexisting liver cirrhosis or nephrotic syndrome with hypoalbuminemia	Interstitial edema	Varies	Varies	< 2.1 cm Collapsibility > 50%	Normal	Varies	Varies	Hydration with colloid

IVC: Inferior vena cava; ECHO: Echocardiography; LVEF: Left ventricular ejection fraction.

image acquisition and interpretation - competencies that often entail a considerable learning curve, especially for junior doctors. Furthermore, variability in patients' body habitus (*e.g.* obesity, abdominal distention) may pose additional challenges in acquiring desirable images. Access to ultrasound equipment may also be restricted in some centres.

CONCLUSION

We suggest the use of a standardized, structured POCUS protocol focusing on key diagnostic parameters, coupled with serial serum lactate measurements for a comprehensive evaluation in managing patients with dengue fever. This approach aims to facilitate earlier identification of at-risk patients, thereby improving patient management, preventing clinical deterioration, and reducing dengue-associated morbidity and mortality.

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FOOTNOTES

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