Point-of-Care Diagnostics in Critical Care: Revolutionizing Bedside Decision-Making

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ABSTRACT

Background: *Point-of-care (POC) diagnostics have emerged as a transformative force in critical care, enabling rapid, bedside decision-making that enhances patient outcomes. In high-stakes environments such as intensive care units (ICUs) and emergency departments (EDs), timely and accurate diagnostic information is crucial for guiding therapeutic interventions and reducing morbidity and mortality. Traditional laboratory-based diagnostics often introduce delays due to sample transport, processing, and result interpretation. In contrast, POC technologies provide immediate results, allowing clinicians to initiate treatment promptly and optimize resource utilization.This review explores the advancements, clinical impact, and challenges of POC diagnostics in critical care. The integration of miniaturized biosensors, microfluidic platforms, and advanced molecular techniques has significantly improved the sensitivity, specificity, and turnaround time of diagnostic tests. Key POC modalities include blood gas analyzers, lactate meters, coagulation testing, and real-time molecular assays for infectious diseases. These tools facilitate rapid assessment of sepsis, acute respiratory distress syndrome (ARDS), myocardial infarction, and metabolic derangements, enabling precision medicine approaches in critically ill patients.Despite their advantages, the widespread adoption of POC diagnostics is met with challenges, including quality control, regulatory constraints, and cost considerations. Variability in operator training and adherence to standardized protocols may impact test reliability, necessitating ongoing quality assurance programs. Additionally, the cost-effectiveness of POC implementation depends on institutional factors such as patient volume, reimbursement policies, and integration with electronic health records (EHRs). Future advancements, including artificial intelligence-driven decision support and connectivity with telemedicine platforms, promise to further enhance the role of POC diagnostics in critical care. In conclusion, POC diagnostics are revolutionizing bedside decision-making by providing rapid, actionable insights that improve patient management in critical care settings. While challenges remain, ongoing technological innovations and strategic implementation will maximize their clinical utility, ensuring that critically ill patients receive timely and personalized interventions.*

Keywords: Point-of-Care Diagnostics , Critical Care

1. INTRODUCTION

Point-of-care (POC) diagnostics have emerged as essential tools in critical care, allowing clinicians to make rapid, data-driven decisions at the bedside. These technologies provide immediate diagnostic insights, enhancing patient outcomes through timely intervention. The integration of POC diagnostics into intensive care units (ICUs) has led to significant advancements in clinical management, particularly in the assessment of hemodynamic status, respiratory function, and infection control [1,2].

Table (1): Advantages and disadvantages of point-of-care diagnostics [2].

Perspective	Advantages	Disadvantages
Patients		
	Fast diagnosis	Cost of POC
	Reduced treatment delay	Need for additional diagnostics
	Reduced morbidity and mortality	Quality of results and related risk
	Reduced length of stay	
	Smaller sample volume	
	Improved patient care and treatment outcomes	
	Avoiding patient and sample misidentification	
	Avoiding patient relocation	
	Patient safety	
Healthcare workers		
	Early recognition of life-threatening conditions	Limited diagnostic possibility
	Immediate and guided treatment of life-threatening conditions	Technical support not immediately accessible
	Immediately available results	Increased work load for ICU personal
	Improved staff efficiency	Storage of equipment
	Eliminated manual transcription of results	Maintenance
	Reduced turnaround time	Calibration and regular quality check
	Precise results due to immediate analysis (blood gas)	Training and recertification for POC technology
	Reduction of need to leave the patient	Results quality
	Improves efficiency of laboratory staff by reducing work load	Misinterpretation of results due to missing expertise
	Reduced administrative work	Exposition to radiation hazard
	Avoiding laboratory work process interruptions due to urgent sample analysis	Handling of biohazard waste
	Avoiding lost sample scenarios	
	Avoiding potential technical problems in steps of sample processing	
	Excluding transport and logistic issues	
	Excluding laboratory result communication from	
	portable POC devices	
	Improved general efficiency and productivity	

Advantages and Challenges of POC Diagnostics

The benefits of POC diagnostics extend across various stakeholders, including patients, healthcare providers, and hospital systems. For patients, POC testing ensures rapid diagnosis, minimizes treatment delays, and reduces morbidity and mortality [3]. Additionally, smaller sample volumes reduce the need for repeated blood draws, enhancing patient safety and comfort [4].

Healthcare professionals benefit from POC testing as it facilitates early recognition and treatment of life-threatening conditions, improves efficiency, and minimizes laboratory workflow interruptions [5]. However, challenges such as limited diagnostic capabilities, the need for technical training, and equipment maintenance persist [6]. The costs of POC technology and concerns regarding the quality and reliability of results compared to centralized laboratory testing remain significant barriers [7].

Ultrasound in Critical Care

Ultrasound (US) has revolutionized intensive care medicine, playing a crucial role in diagnostics, procedural guidance, and patient monitoring. The ability to assess systemic blood flow, cardiac output, and venous congestion using Doppler ultrasound has transformed shock resuscitation strategies [8]. Doppler-based techniques evaluating renal and splanchnic circulation have demonstrated a correlation between abnormal flow and organ dysfunction, reinforcing the role of ultrasound in optimizing hemodynamic support [9].

During the COVID-19 pandemic, lung ultrasound gained prominence, with advancements such as contrast-enhanced ultrasound (CEUS) and Doppler-based techniques improving the assessment of pulmonary conditions [10]. These innovations have refined ventilatory management strategies, including positive end-expiratory pressure (PEEP) optimization and weaning protocols.

Airway Management and Ultrasound

Ultrasound is increasingly used in airway management, providing real-time guidance for tracheal intubation, cricothyrotomy, and tracheostomy. Sonographic assessment allows rapid identification of the tracheal position, aiding in emergency airway procedures, particularly in patients with difficult anatomical features [11].

The **Tracheal Rapid Ultrasound Exam (TRUE)** technique has proven highly effective in confirming endotracheal tube (ETT) placement, with a sensitivity of 98.9% and specificity of 94.1% [12]. This approach is especially beneficial when conventional auscultation or capnography is unreliable. Additionally, lung ultrasound can confirm correct ETT positioning by detecting lung sliding and ruling out esophageal intubation [13].

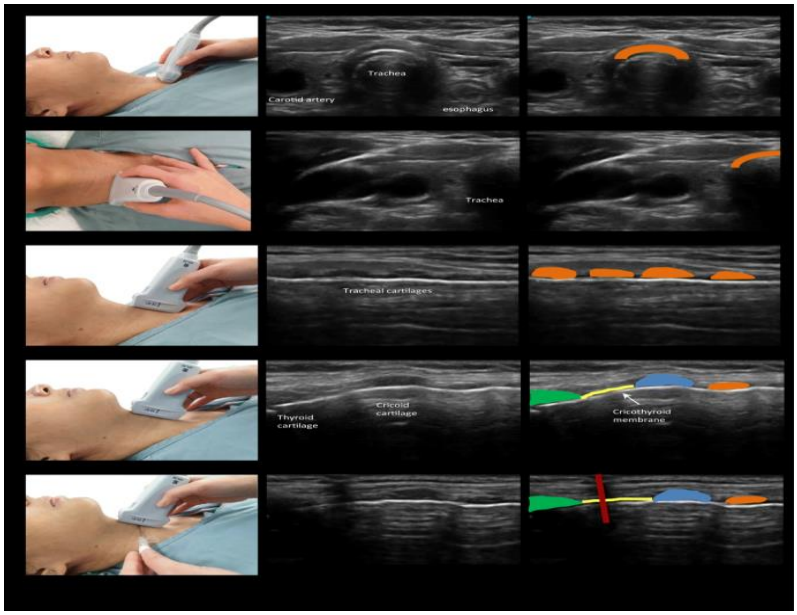

Figure (2):The longitudinal "string-of-pearls" (SOP) technique for identifying the cricothyroid membrane and tracheal interspaces. White, air-tissue border; orange, tracheal cartilage; blue, cricoid cartilage; green, thyroid cartilage; yellow, cricothyroid membrane; red, shadow cast by the needle when placed between the transducer and skin (see text for detailed explanation) [13].

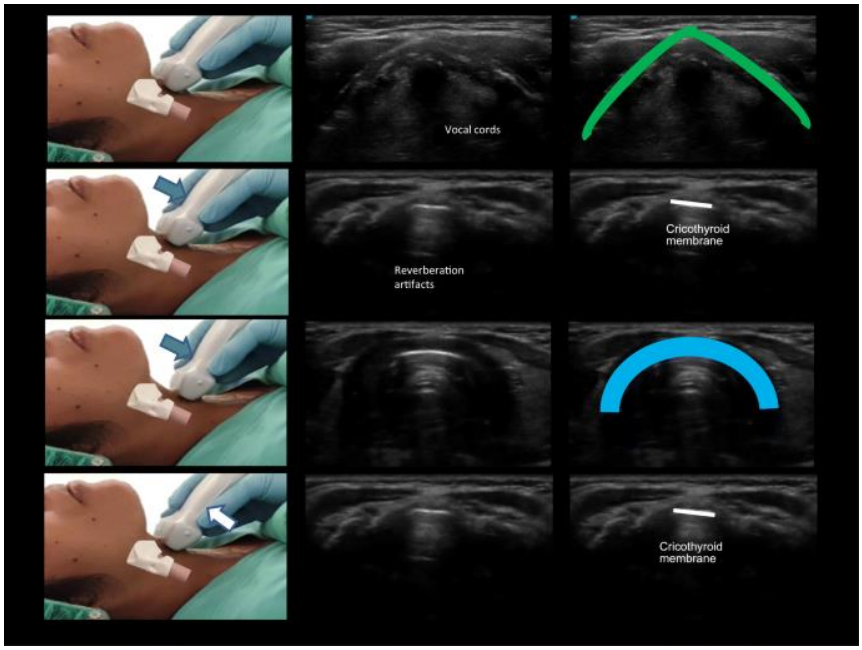

Figure (3): The transverse "thyroid-airline-cricoid-airline" (TACA) technique. Green, triangular thyroid cartilage; white, airline-cricothyroid membrane; blue, the anterior part of the cricoid cartilage (see text for detailed explanation [13].

Transcranial Doppler and Intracranial Pressure Monitoring

Transcranial Doppler (TCD) is a valuable POC tool for evaluating cerebral hemodynamics, detecting intracranial hypertension, and monitoring autoregulatory function. Pulsatility index (PI), mean flow

velocity (MFV), and Lindegaard ratio are among the key TCD-derived parameters used in critical care [14].

The optic nerve sheath diameter (ONSD) measurement has emerged as a promising non-invasive technique for estimating intracranial pressure (ICP). The correlation between ONSD and cerebrospinal fluid pressure offers an alternative to invasive ICP monitoring, reducing the risk of complications such as hemorrhage and infection [15].

Table (2): Common parameters derived from transcranial Doppler (Robba and Taccone, 2019)

	Abbreviation or formula	Normal values	Cerebral autoregulation
Pulsatility index	PI = (sFV − dFV)/mFV	< 1.4	
Mean FV	Mfv	60–80 cm/s	
Diastolic FV	Dfv	> 20 cm/s	
Mean flow index	Mx	< 0.3	> 0.3 (impaired)
Lindegaard ratio	LR = mFV MCA/mFV extracranial ICA	< 3	
THR test			Less than 10% increase from baseline sFV (impaired)
FV flow velocity, MCA middle cerebral artery, ICA internal carotid artery, Mx mean flow index, dFV diastolic flow velocity, mFV mean flow velocity, sFV systolic flow velocity, CA cerebral autoregulation, THR transient hyperemic test			

Name of Doppler device parameter	**Main functions**
Mean velocity evaluation	This exam supply evaluation of the precision of the Doppler system's evaluate of the mean Doppler scattered speed. In addition to the precision of the colour Doppler evaluate of the mean scattered speed
Range gate	Helps reveal blood flow signal wave
Sample volume or sample length	This exam evaluate the sensitivity of range gate to make sure if it is extreme sensitive at the centre position of the gate
Maximum velocity precision	This exam supply evaluation of the precision of the Doppler system's evaluate of the maximum Doppler scattered speed. In addition to the precision of the reveal the degree of arterial narrowing or stenosis
Lowest detectable speed	This exam supply evaluation of the lowest speed that it is likely to show unambiguously
Highest detectable speed	This exam supply evaluation of the highest speed that it is likely to show unambiguously on both the colour Doppler image or on the PW Doppler spectrum. The highest speed with some diseases or stenosis may be reach up to 500-600

	cm/s and can show this speed on the spectrum without aliasing
Spectral broadening	This exsam supply evaluation of the spectral Doppler broadening which cause by range of angles
Flow direction	This exam supply ability of the differentiate between flow towards and away from the probe
Angle correction	This exam supply ability to measures the accuracy of the angle correction the device
Wall filter	This exam remove intense signals from the vessel wall motion

POC Diagnostics in Shock and Hemodynamic Monitoring

The Rapid Ultrasound in Shock (RUSH) protocol is an essential framework for evaluating shock etiologies at the bedside. This approach categorizes diagnostic findings into three components: pump (cardiac function), tank (intravascular volume), and pipes (vascular integrity) [16].

This exam protocol was first developed in 2006 by Weingart et al., and further elaborated by Perera et al. in 2010 [27]. The protocol is based on the notion that each pathophysiologic etiology of shock (distributive, obstructive, cardiogenic, hypovolemic) will produce physiologic features easily distinguishable by ultrasonography. In order to provide a framework for using ultrasound, the authors use a conceptual "plumbing" model to categorize the sonographic features into three main essential categories: pump, tank, and pipes [28].

The Pump

The pump refers to the function and pathology surrounding the heart. The focused 4-view echocardiographic exam (PLAX, PSAX, A4C, and SX) can rapidly narrow the diagnosis to several etiologies of shock. When assessing the heart, pay particular attention to pericardial effusions, ventricular function, and relative chamber size [29].

Pericardial effusions can be identified in any of the 4 focused views; however, the subxiphoid/subcostal and PLAX views are most frequently utilized because they allow for long-axis assessment of the largest amount of pericardium. In the PLAX view, it is helpful to set the depth high enough to visualize the descending aorta [30].

Pericardial effusions can be confirmed as fluid layering anterior to the aorta, whereas pleural effusions will be present posterior to and lateral to the descending aorta. Once an effusion is found, it may be difficult to differentiate tamponade from an asymptomatic effusion in the emergent setting [31].

Due to the relatively low pressures in the right ventricle (RV) compared to the left ventricle (LV), outflow from the RV is preferentially obstructed first. Identification of right heart failure is critical in the detection of this "tamponade" physiology. Collapse of the right ventricle during diastole (when it should normally be filling) is specific for tamponade (75–90% specificity) [31].

By contrast, collapse of the right atrium during late systole (when it should normally be full) may be sensitive to tamponade. Absence of collapse in either chamber carries a 90% sensitivity to rule out tamponade physiology in the presence of effusion [32].

For the left ventricle, one ought to focus particularly on systolic function. This is most easily done by observing the movement of the walls of the left ventricle in the PLAX and PSAX views. Cardiogenic shock presents with poor systolic pump function, and in this case, the walls will appear hypodynamic with poor movement inward during systole [33].

One can also observe the movement of the mitral valve during diastole. In diseases with poor cardiac contractility, the mitral valve will have diminished movement, whereas during normal or hyperactive contractility, the mitral valve will have more pronounced movement, reaching the interventricular septum during end-diastole [34].

In contrast to cardiogenic shock, hypovolemic and distributive shock present the heart with low preload and typically display substantially increased cardiac contractility, referred to as hyperdynamic function [35]. This is seen in the PLAX and PSAX views as near-complete obliteration of the ventricular space during systole [36].

Unlike the left ventricle, the right ventricular wall has much higher compliance so that stress on the right ventricle can be reflected by dramatic alterations in RV morphology. Relative to the thicker-walled, concentric, and large LV, the normal RV is thin-walled, irregularly shaped, and is typically only 2/3 the size of the LV [37].

Acute RV strain, as can be seen in pulmonary embolism, will result in acute dilatation of the RV diameter with a relatively thin RV free wall, best seen in the A4C view. Chronic RV strain and heart failure can be seen in chronic lung disease or pulmonary hypertension. In this case, the RV also appears enlarged, but the RV free wall will be hypertrophied and thick (>5 mm when measured in diastole) [38].

The Tank

The tank refers to the status of the compartments responsible for cardiac preload. For the right ventricle, the tank can be assessed through the inferior vena cava (IVC) and by evaluating for causes of volume loss such as AAA rupture, hemoperitoneum, or hemothorax. For the left ventricle, the tank can be assessed by evaluating lung function and volume status (Fig. 13) [39].

IVC Overview

The IVC is best evaluated from a modified subxiphoid approach. It is traditionally measured in the sagittal orientation, although, if appropriately identified, it can also be evaluated in the transverse orientation [40]. The diameter of the IVC varies substantially as it traverses the abdomen, and by convention, it is typically measured 1–3 cm distal to the right atrium, just proximal to the confluence

of the hepatic vein with the IVC. During evaluation of the IVC, focus on the size and collapsibility of the IVC [41].

IVC Size

It has been shown that there is a moderate correlation between IVC size and central venous pressure (CVP) or right atrial pressure (RAP). Traditionally, an IVC maximal diameter <2.1 cm has been considered small, correlating with a low CVP, and an IVC >2.1 cm has been considered large, correlating with a high CVP [42]. However, more data have emerged suggesting that the normal range may be much wider. It was suggested that the correlation of the IVC with CVP is useful at the extremes. Thus, an IVC diameter <1.5 cm appears to be relatively specific for volume responsiveness, while an IVC diameter >2.5 cm is specific to lack of volume responsiveness [43].

IVC Collapsibility and Distensibility

In addition to size, the IVC changes diameter during respiration due to changes in venous return. During negative pressure/normal breathing, the IVC will collapse during inspiration. During positive pressure/mechanical ventilation, the IVC will distend during inspiration [44].

This finding of change in size is generally more pronounced when the RV preload is low (hypovolemic states). A collapsibility or distensibility index can be calculated as a percentage of collapse:

IVCmax−IVCminIVCmin×100%\frac{IVC_{max} - IVC_{min}}{IVC_{min}} \times 100\%IVCminIVCmax−IVCmin×100%

A change of >50% is consistent with hypovolemia, while a change of <50% will be consistent with hypervolemia [45].

Again, these findings are most reliable at their extremes, and care should be used when interpreting these values if they are unclear. Additionally, one must ensure that the IVC remains in plane throughout respiration, as it may be difficult to determine whether the change in diameter represents true collapsibility rather than the movement of the IVC out of the sonographic plane [46].

To address this, ensure that the patient is breathing normally (do not ask the patient to "take a deep breath") or perform the sniff test, by asking the patient to sniff. This results in less diaphragmatic excursion and out-of-plane movement [47].

IVC Summary

The evaluation of the IVC has been controversial, as it is unclear whether IVC appraisal accurately reflects "volume responsiveness" or merely correlates with CVP, which is known to be a suboptimal reflection of actual volume responsiveness [48].

Additionally, IVC size can be altered by obstructive shock, and care should be taken to ensure that IVC assessment occurs in concert with cardiac and occasionally DVT evaluation to ensure that the dilated IVC is not a consequence of RV obstruction (tamponade or PE) rather than hypervolemia [49].

IVC sonography is helpful at the extremes; however, intermediate findings may be frustrating. In cases where the IVC does not provide an obvious answer, consider serial dynamic ultrasound during fluid loading to assess for changes in RV preload throughout resuscitation [50].

Lungs and the LV "Tank"

The assessment of the "tank" must also include the compartment containing the LV preload: the lungs. Indeed, the most common way that rapid administration of volume will cause harm is by overloading this compartment, leading to pulmonary edema, hypoxia, and worsening cardiac ischemia in an already critically ill patient [51].

Assessment of the lungs includes evaluation of bilateral B-lines indicating alveolar interstitial syndrome (AIS) and pleural effusions indicating likely preload overload of the LV [52].

It is important to remember that AIS exists on a spectrum: ESRD or CHF patients commonly have some B-lines without any compromise to the LV or oxygenation. However, if there are >3 B-lines present in all fields, the clinician should be wary of aggressive volume repletion without also addressing the contribution of cardiogenic shock to the overall picture [53].

While evaluating the lungs, one should also evaluate the pleural line for the presence of sliding and a lung point. Findings suggestive of pneumothorax in a hypotensive patient should raise concern for tension pneumothorax and rapidly change management. In this way, evaluation of the "tank" can guide management beyond volume status and aid in the identification of obstructive causes of shock [54].

Tank Losses

When there is suspicion for hemorrhagic shock (e.g., trauma, ectopic pregnancy, or other solid organ bleeding), the eFAST exam (including lower lung views to evaluate for hemothorax) can also be a useful adjunct to the assessment of the right ventricular preload tank [55].

In the proper clinical context, this may indicate the need for blood product administration rather than crystalloid. On the other hand, in concert with a history of heart failure seen on echocardiogram, this may represent volume overload (ascites, pleural effusion) and may indicate cardiogenic shock. Thus, the evaluation of the tank is closely linked to evaluation of the pump and clinical history and should not be interpreted in isolation [56].

Aorta Background

The abdominal (rather than thoracic) aorta is most amenable to bedside ultrasound evaluation for the detection of an abdominal aortic aneurysm (AAA). A ruptured AAA can cause profound hemorrhagic shock, and because the bleeding is often retroperitoneal, initial presentations can be occult and difficult to diagnose [59].

Aortic dissection can also occur, though it frequently begins in the thoracic aorta, which is more challenging to visualize using bedside ultrasound. Moreover, many patients with aortic dissections initially present with hypertension and may not be obvious candidates for the RUSH exam [60].

On ultrasound, an aortic dissection may appear as a hyperechoic linear "flap" within the vessel lumen. However, ultrasound is less sensitive for thoracic aortic dissection than CT angiography, and artifacts may mimic a dissection flap. While prehospital and austere environments should be familiar with the presentation and pathophysiology of aortic dissection, this section will primarily discuss ruptured AAA [61].

The classic patient with an AAA is an older male smoker. However, individuals with connective tissue disorders, such as Marfan syndrome, are also at increased risk. Additional risk factors include a positive family history, the presence of other vascular aneurysms, atherosclerosis, and advanced age. The incidence of AAA is four times higher in men than women, though women appear to have a higher-than-expected rate of rupture and associated mortality [62].

AAAs are frequently asymptomatic until rupture occurs. Consequently, many patients remain unaware of their aneurysm, even though it has likely been enlarging for years. While the majority of aneurysms never rupture, those that do can cause rapid hemorrhage and cardiovascular collapse. Once rupture occurs, mortality increases significantly every hour, making this a time-sensitive condition requiring emergent treatment [63].

Rupture results when the weakened vascular wall fails, leading to extravasation of blood, often into the retroperitoneal space. Only about 50% of patients with a ruptured AAA survive long enough to receive medical care, highlighting the high mortality rate of this condition [64].

Among those who reach medical care, many cases involve retroperitoneal or partially contained rupture, which complicates diagnosis. Due to vague symptoms, up to 30% of all AAAs are initially misdiagnosed, often mistaken for renal colic or musculoskeletal back pain. A high index of suspicion and attention to risk factors are critical for accurate diagnosis [65].

Due to increased screening, some patients may be aware of their AAA even when asymptomatic, making it relevant to inquire about prior diagnoses. Common symptoms include back or abdominal discomfort, dizziness, lightheadedness, and other early shock symptoms. Some patients may also exhibit signs of lower extremity vascular compromise due to reduced perfusion or intraluminal thrombus embolization [66].

On physical examination, a palpable, pulsatile abdominal mass may be present in the midline. A bruit or thrill may also be auscultated. In cases of acute rupture, particularly if intraperitoneal, there may be abdominal tenderness and signs of peritonitis, such as rigidity [67].

Retroperitoneal bleeding can lead to classic physical exam findings, including Cullen’s sign (periumbilical ecchymosis), Grey-Turner’s sign (flank ecchymosis), and Bryant’s sign (scrotal ecchymosis). If a critically ill patient has a presentation consistent with a ruptured AAA and ultrasound confirms an aneurysm, rupture should be presumed as the likely diagnosis [68].

Ultrasound findings may occasionally visualize clot formation or asymmetry suggestive of contained rupture, though specific sonographic signs of rupture are often absent. Thus, diagnosis should be based on the presence of an AAA in conjunction with clinical history and examination findings. Additionally, because most AAAs rupture through the posterior wall into the retroperitoneal space, a FAST exam may not detect free intraperitoneal fluid [69].

Aorta Ultrasound Anatomy

The abdominal aorta can generally be visualized from the epigastrium to the umbilicus. Although the aorta gradually enlarges with age, standard measurement guidelines remain consistent [70].

An aneurysm is defined as a segmental, full-thickness dilation of a blood vessel 50% greater than its normal diameter. Most guidelines classify an aorta as aneurysmal if it exceeds 3 cm in diameter. The larger the aneurysm, the greater the risk of rupture [71].

During routine ultrasounds, aortic measurements between 3 and 5 cm warrant close monitoring, while aortas measuring between 5 and 7 cm typically require urgent surgical intervention. Aortas exceeding 7 cm necessitate emergent surgical management. However, rupture can occur at any size, underscoring the importance of clinical context in decision-making [72].

Key vascular landmarks help confirm aortic identification. The most proximal landmark is the celiac artery, which arises anteriorly from the aorta and forms the “seagull sign” in the transverse view, with the splenic and hepatic arteries forming the wings. Another critical landmark is the superior mesenteric artery (SMA), which appears as a "mantle clock" in the transverse plane. Most AAAs are infrarenal, necessitating scanning through the iliac bifurcation, which lies distal to these vessels [73].

Aorta Ultrasound Overview

Early identification of a ruptured AAA as the cause of shock can be lifesaving. In this case, the primary shock subtype is hemorrhagic. Management should follow the principle of **permissive hypotension**, prioritizing early blood product administration. If blood products are unavailable, judicious use of small crystalloid boluses can help maintain perfusion without overcorrection [74].

Patients should be transferred as quickly as possible to a facility with vascular surgery capabilities for definitive care. Ideally, the receiving center should be pre-alerted so the blood bank and surgical team can mobilize in advance [75].

Ultrasound examination of the aorta during the RUSH protocol is invaluable. If no aneurysm is found, ruptured AAA can be effectively ruled out. However, if an AAA is detected, clinical suspicion for rupture must remain high, guiding patient resuscitation and disposition [76].

Aorta Ultrasound Technique

The curved abdominal probe is typically best for visualizing the aorta. A deeper imaging depth of 15–17 cm may be required to visualize the most proximal segment of the abdominal aorta, as it becomes more superficial distally [77].

Apply a generous amount of gel along the midline, from the xiphoid to the umbilicus. Position the probe just below the xiphoid process with the marker directed to the patient's right to obtain a short-axis view [78].

The easiest structure to identify first is the **spinal stripe**, a hyperechoic crescent-shaped structure with a distinct posterior shadow. The aorta is typically situated superiorly and slightly to the patient's left of the spinal stripe. Confirming the **celiac artery take-off** ensures that scanning begins at the correct proximal location [79].

The probe should then be moved distally, following the aorta until it bifurcates into the iliac arteries at the umbilicus. Smooth, consistent pressure helps maintain steady imaging and displace bowel gas that may obscure visualization [80].

For additional clarity, a longitudinal view of the aorta can be helpful. This allows for a better comparison of aneurysmal dilation relative to the rest of the vessel [81].

A common pitfall is mistaking the **inferior vena cava (IVC)** for the aorta. Using the **spinal stripe** as a reference can help differentiate them. Additionally, in the longitudinal view, the spine should produce a "scalloped" appearance beneath the aorta. Lastly, the aorta exhibits a more pulsatile nature than the IVC [82].

Cardiogenic shock is characterized by reduced left ventricular function and increased venous congestion, whereas obstructive shock due to pulmonary embolism is identified by acute right ventricular dilation and venous thrombosis [17]. In hypovolemic shock, ultrasound findings include a small, hyperdynamic left ventricle and a collapsible inferior vena cava (IVC), while distributive shock presents with a hyperdynamic heart and reduced systemic vascular resistance [18].

Focused Cardiac Ultrasound (FoCUS) in Critical Care

FoCUS has become a cornerstone of hemodynamic assessment, allowing real-time evaluation of left and right ventricular function, pericardial effusions, and valvular pathology. The identification of **right ventricular strain** is crucial in diagnosing pulmonary embolism, while a hyperdynamic left ventricle suggests hypovolemia [19].

Cardiac ultrasound also plays a pivotal role in fluid management by assessing IVC collapsibility and lung ultrasound B-lines to monitor volume overload [20]. The combination of these techniques helps optimize fluid resuscitation strategies, avoiding iatrogenic complications.

Lung and Pleural Ultrasonography

Lung ultrasound is an invaluable bedside tool for diagnosing pneumonia, pulmonary edema, and pleural effusions. The **BLUE protocol** (Bedside Lung Ultrasound in Emergency) enables rapid differentiation of acute respiratory failure causes based on lung aeration patterns [21].

The **FALLS protocol (Fluid Administration Limited by Lung Sonography)** guides fluid therapy in sepsis by monitoring B-line progression, which reflects worsening pulmonary edema [22]. These ultrasound-based strategies have redefined critical care management by enabling individualized, dynamic treatment adjustments.

Abdominal and Vascular POC Ultrasound

Abdominal ultrasound is widely used to evaluate free fluid in trauma patients and detect conditions such as ascites, hydronephrosis, and cholecystitis. Focused assessment with sonography for trauma (FAST) has become a standard in emergency settings for identifying hemoperitoneum and guiding immediate interventions [23].

Additionally, bedside ultrasound facilitates the early detection of **deep vein thrombosis (DVT)** using **compression ultrasonography**, reducing the time to anticoagulation therapy in critically ill patients [24].

Ultrasound-Guided Procedures

The integration of ultrasound guidance into procedural interventions has significantly improved safety and accuracy. **Ultrasound-guided central venous catheter (CVC) placement** has reduced complications such as pneumothorax and arterial puncture, making it the standard of care [25].

Similarly, **ultrasound-assisted lumbar puncture and paracentesis** have enhanced procedural success rates while minimizing adverse events. The ability to visualize anatomical structures in real time has contributed to improved patient safety and procedural efficiency [26].

Conclusion

Point-of-care diagnostics have transformed critical care by enabling rapid, accurate decision-making at the bedside. The integration of ultrasound-based modalities in hemodynamic monitoring, airway management, and procedural guidance has revolutionized patient care. While challenges such as cost, training, and quality assurance persist, ongoing advancements in POC technology continue to refine critical care practices. The future of POC diagnostics lies in enhanced automation, artificial intelligence integration, and improved accessibility, paving the way for a new era of precision medicine in intensive care settings.

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