The CORE Scan
Concentrated Overview of Resuscitative Efforts

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INTRODUCTION

Critically ill patients require rapid, accurate assessments and appropriate therapeutic interventions to maximize their chances of recovery. Often, the cause of a patient’s decompensation is not readily apparent based solely on history and physical examination findings. Furthermore, the evaluation of resuscitation efforts is often difficult because of the time-intensive and invasive nature of most monitoring techniques. The use of bedside ultrasonography has been successfully integrated universally into the assessment of patients presenting with acute traumatic injury.\(^1\)\(^2\) Various protocols are also being studied regarding the use of bedside ultrasonography in the evaluation of patients presenting with shock and undifferentiated hypotension, and during volume resuscitation.\(^3\)\(^-\)\(^6\) This article describes a compendium of bedside scans that should be performed during the assessment and management of critically ill patients. The CORE (Concentrated Overview of Resuscitative Efforts) scan can be used to help make critical diagnoses and guide resuscitation efforts in patients with undifferentiated deterioration.

ENDOTRACHEAL TUBE ASSESSMENT

The first part of the CORE scan addresses the patient’s airway. Traditionally, assessment of proper endotracheal tube placement has been performed using methods such...
as direct laryngoscopy, auscultation of breath sounds, end-tidal CO₂ detection, and chest radiography. Ultrasonography has been shown to be useful in determining proper endotracheal tube positioning at the bedside. During intubation attempts, a linear-array transducer can be placed in a horizontal fashion across the patient’s neck, at the level of the cricothyroid membrane. The orientation marker on the probe is typically oriented toward the patient’s right (Fig. 1).

With the probe in this position, the patient’s thyroid can be visualized nearfield on the screen, with the bright white hyperechoic rings of the trachea just farfield to it (Fig. 2). As the endotracheal tube is being passed down through the trachea, the bright white hyperechoic tube can be visualized entering the tracheal lumen. The tube will cast a white acoustic shadow farfield on the screen once it is in the lumen of the trachea (Fig. 3).

On ultrasonography, the esophagus can be seen as a muscular ring just posterolateral to the trachea. During the intubation, applying color Doppler over the trachea can help visualize movement of the endotracheal tube as it is advanced into the trachea (Fig. 4).

If the endotracheal tube is accidentally passed into the esophagus, the comet tails from the tube will be seen in the esophagus, and a flash of color will be seen on color Doppler imaging of the esophagus during the failed intubation attempt (Fig. 5).

Endotracheal ultrasonography can be useful in guiding proper tube placement during the initial intubation attempt, or for reassessment of tube placement following patient transfer, repositioning, or changes in a patient’s respiratory status. Performing bedside ultrasonography to determine tube positioning is faster than performing a direct laryngoscopy, and carries less risk of accidentally dislodging the endotracheal tube. Once the endotracheal tube has been confirmed to be properly in the trachea, it is useful to evaluate the lungs for symmetric, bilateral lung inflation and lung sliding during ventilation and oxygenation attempts.

**BEDSIDE PULMONARY ULTRASONOGRAPHY**

The CORE scan can be modified based on the clinical suspicion of what is likely contributing to a patient’s deterioration. In most situations, once the endotracheal tube position has been confirmed within the trachea, it is useful to evaluate the lungs as the next step. A thoracic ultrasonographic scan can be completed quickly at the

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**Fig. 1.** Ultrasonographic evaluation of endotracheal tube placement. Note that the indicator marker should be directed toward the patient’s right side.
bedside to determine whether the patient has ventilation of both lungs and to assess whether the patient has a pneumothorax or pleural effusion that needs to be urgently addressed.

The lungs can be visualized by placing either a high-frequency linear-array transducer or a lower-frequency curvilinear transducer in a horizontal fashion in the second or third intercostal space (Fig. 6).

With the probe in this position, the parietal and visceral pleural interface can be seen as a bright white hypoechoic line coursing horizontally across the ultrasound screen.

**Fig. 2.** Ultrasonographic visualization of the hypoechoic tracheal rings and empty trachea behind the thyroid tissue.

**Fig. 3.** Endotracheal tube within the tracheal lumen producing a hypoechoic comet-tail farfield.
For patients in whom it is difficult to identify the pleural line, begin the scan with the probe in a longitudinal fashion, at the third intercostal space, along the midclavicular line; this will provide a view of the ribs and underlying structures. To ensure proper visualization of the parietal-visceral pleural interface, locate an anechoic rib and focus on the hyperechoic line just farfield to the rib (Fig. 7).

During the normal inspiratory and expiratory cycle, the visceral pleura can be seen gliding along the parietal pleura. On ultrasonography, this horizontal to-and-fro movement across the screen has been termed lung sliding.8 If a patient is intubated with the endotracheal tube in the proper position, bagging the patient should produce bilateral lung sliding with each ventilation. If the endotracheal tube is in the right main-stem bronchus, there will be an absence of lung sliding on the left. Similarly, with

Fig. 4. Improving visualization of the endotracheal tube entering the trachea using color Doppler.

Fig. 5. Comparison of color Doppler imaging of the endotracheal tube entering the trachea (left) versus the esophagus (right). A, carotid artery; Es, esophagus; Tr, tracheal rings.
an endobronchial intubation on the left, lung sliding will not be seen over the right hemithorax.

If lung sliding is difficult to visualize, or if a unilateral pneumothorax is suspected, the next step is to evaluate the diaphragm for bilateral, symmetric excursion. The diaphragm is best visualized by placing a lower-frequency curvilinear or phased-array transducer in a longitudinal fashion along the midaxillary line at the T7-T9 intercostal space (**Fig. 8**). With the indicator pointing toward the patient’s head, the diaphragm will appear as a bright white hyperechoic line just to the left of the liver or the spleen (**Fig. 9**).

Compare the excursion of the diaphragm on both the left and right sides of the chest. If there is no lung sliding and no diaphragmatic excursion, the patient has an endobronchial mainstem intubation, a large unilateral airway obstruction, or a very large pneumothorax.

**Fig. 6.** Linear array transducer and probe placement for a thoracic ultrasound.

**Fig. 7.** Bedside ultrasound of the parietal-visceral pleural interface in between 2 anechoic ribs.
On ultrasonography, a normal lung typically demonstrates lung sliding and artifacts called comet tails. Comet tails are bright white hyperechoic artifacts that shoot farfield off the pleural interface when the parietal and visceral pleura appose one another during the respiratory cycle (Fig. 10). If there is air trapped in between the parietal and visceral pleura, comet tails and lung sliding will not be visualized.

When normal lung is visualized on M-mode, a characteristic pattern termed the seashore sign is seen (Fig. 11). The seashore sign depicts a normal interface between the lung and chest wall, where the static thoracic wall and soft tissue produces parallel lines across the screen. The pleural line is seen as a bright white horizontal line.
separating the soft tissue nearfield and the dynamic lung parenchyma farfield. If the patient has a pneumothorax, the M-mode imaging of the lung will produce a pattern called the stratosphere sign or bar-code sign (Fig. 12). This pattern is seen on M-mode because the air trapped in between the parietal and visceral pleura produces horizontal hyperechoic artifacts in the farfield.

If there is concern that there may be a pneumothorax instead of just an endobronchial mainstem intubation, scan along the chest until the edge of the pneumothorax is visualized. The transition point between normal lung and a pneumothorax is called the lung point.⁹ At the lung point, normal lung sliding and comet tails will be seen abutting a region of the pleura where there is a distinct absence of lung sliding or comet tails. With B-mode scanning, it is easy to see the transition between the normal lung sliding across the screen and the stationary pneumothorax in real time (Fig. 13). On M-mode, if the cursor is placed directly over the lung point, a clear transition between the seashore sign and the bar-code sign will be observed (Fig. 14).

If thoracic ultrasonography does not demonstrate lung sliding and the lung point cannot be clearly visualized, it may be difficult to determine whether the patient has a pneumothorax or an endobronchial intubation. To help distinguish between the two entities, scan the lung for a lung pulse. The lung pulse is the detection of cardiac...
Fig. 12. The stratosphere sign or bar-code sign of a pneumothorax in M-mode.

Fig. 13. A static image of the transition between normal lung and a pneumothorax at the lung point. In real-time B-mode scanning, the movement of the normal lung will be in distinct contrast to the stationary pneumothorax.

Fig. 14. Lung point on M-mode. Note the transition between the bar-code sign of a pneumothorax and the seashore sign of normal lung.
pulsations transmitted to the parietal pleura in a lung that is not being actively ventilated, and is best visualized on M-mode. A lung pulse should not be visualized with a large pneumothorax. It is important to remember that lung sliding can be absent in patients who have had a pleurodesis, or who have pleural adhesions, pulmonary contusions, pulmonary infiltrates, acute respiratory distress syndrome, atelectasis, bullae, blebs, large pulmonary contusions, or pulmonary masses abutting the pleural line. Further research is being undertaken to help distinguish between these entities on bedside ultrasonography.

During the thoracic portion of the CORE scan, it is useful to know if the patient has a large pleural effusion that may require immediate intervention. Pleural effusions are best visualized by placing the probe in the mid- to posterior-axillary line between T7 and T10. Attempt to visualize the interface between the inferior lung and the diaphragm. A pleural effusion will appear as a dark anechoic layer of fluid just cranial to the diaphragm. Lung may be seen floating in the effusion during the respiratory cycle (Fig. 15).

If the pleural effusion is thought to be contributing to the patient’s deterioration, an emergent thoracostomy tube should be placed to drain the fluid noted on ultrasonography.

The CORE scan may demonstrate findings of pulmonary edema. Patients with clinically significant pulmonary edema will demonstrate large “B-lines” or “lung rockets” (Fig. 16). Lung rockets are bright white hyperechoic comet tails that move with sliding of the lung, and are the result of interlobular septa filled with water. These features are wider than the comet tails seen in normal lung, and should extend to the farfield depths of the ultrasound image. Patients with pulmonary edema should demonstrate more than two lung rockets in at least two areas of the thoracic cavity. Current research is under way to determine whether the number of lung rockets correlates with the degree of pulmonary edema. If lung rockets are visualized during the CORE scan, resuscitation and management options for alveolar-interstitial syndrome should be instituted accordingly.

**BEDSIDE CARDIAC ULTRASONOGRAPHY**

During the CORE scan, it is imperative to evaluate the heart to establish that the patient still has cardiac activity; to note if there is a pericardial effusion and cardiac tamponade; to assess for any right ventricular strain that may indicate the presence of a
large pulmonary embolism; to determine whether the patient requires more intravascular volume; and to evaluate the estimated ejection fraction of the heart.

To perform a rapid assessment of the heart during resuscitation attempts, it is ideal to start with a parasternal long-axis view of the heart. First, identify that the patient still has cardiac activity and that chest compressions are not warranted. Once cardiac activity has been visualized, assess for the presence of a pericardial effusion and cardiac tamponade. Pericardial fluid will appear as a dark anechoic stripe of fluid surrounding the heart. If the effusion is small, it may only be seen as a small black stripe of fluid along the posterior, dependent portion of the pericardial sac (Table 1). Larger effusions will be seen circumferentially around the heart and are typically more than 15 mm in diameter (Fig. 17).

The presence of a moderate or large pericardial effusion does not necessarily mean that the patient has cardiac tamponade. Ultrasonographic findings of cardiac tamponade include end-diastolic right ventricular collapse (Fig. 18), right atrial collapse, respiratory variation of blood flow across the tricuspid or mitral valve of more than 40%, and a dilated inferior vena cava (IVC) that does not change with inspiration or “sniffing” (Fig. 19).10,11 If tamponade physiology is noted clinically or on bedside ultrasonography of the heart, a pericardiocentesis should be performed immediately under ultrasound guidance.12

If there is clinical suspicion for a large pulmonary embolism causing hemodynamic compromise, bedside cardiac ultrasonography can be performed to assess for right ventricular dilation (>1:1 right ventricular/left ventricular diameter) (Fig. 20), right ventricular systolic dysfunction, paradoxic septal bowing into the left ventricle (Fig. 21), IVC dilation without inspiratory collapse (Fig. 22), or presence of thrombus visualized in the right ventricle.13 On a parasternal short-axis view of the heart, the septum may be seen bowing into the left ventricle, thereby creating the so-called D-sign from right

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**Table 1**

<table>
<thead>
<tr>
<th>Effusion Size</th>
<th>Location</th>
<th>Diameter (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>Localized, dependent region</td>
<td>&lt;10</td>
</tr>
<tr>
<td>Medium</td>
<td>Localized or circumferential</td>
<td>10–15</td>
</tr>
<tr>
<td>Large</td>
<td>Circumferential</td>
<td>&gt;15</td>
</tr>
</tbody>
</table>

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Fig. 16. “Lung rockets” from a patient with acute pulmonary edema.
Fig. 17. Large pericardial effusion surrounding the heart. Ao, aortic outflow tract; LA, left atrium; LV, left ventricle; RV, right ventricle.

Fig. 18. End-diastolic collapse of right ventricle (RV) from a pericardial effusion causing cardiac tamponade.

Fig. 19. Dilated inferior vena cava (IVC) from a pericardial effusion causing cardiac tamponade.
Fig. 20. Right ventricular (RV) dilation from a massive pulmonary embolism. RA, right atrium; RV, right ventricle; LA, left atrium; LV, left ventricle.

Fig. 21. Septal bowing into the LV, otherwise known as the D-sign, on parasternal short-axis view of the heart.

Fig. 22. Dilated IVC from a large pulmonary embolus (26.5 mm).
ventricular dilation. In this view, instead of its typical circular appearance, the left ventricle appears more like the letter D (see Fig. 21).

It is important to bear in mind that these sonographic findings must be taken in the context of the entire clinical picture, as many of these findings can also be seen with long-standing chronic obstructive pulmonary disease, obstructive sleep apnea, pulmonary hypertension, and right-sided myocardial infarction. Evaluation of the diameter of the right ventricular wall can help distinguish between acute and chronic right ventricular dilation and right ventricular dysfunction. Patients with chronic right ventricular strain will typically have a right ventricular wall thickness greater than 6 mm. In addition, most patients with chronic right ventricular dysfunction will demonstrate global hypokinesis, whereas patients with a large, acute pulmonary embolism may exhibit hypokinesis of the right ventricular free wall and base, but normal contractility of the right ventricular apex. This apical sparing is known as the McConnell sign, and has been shown to have specificity of 94% and sensitivity of 77% for diagnosing an acute pulmonary embolism.

These findings on the CORE scan in a hemodynamically unstable patient or in a patient in cardiac arrest should prompt the clinician to consider a large pulmonary embolism, and to contemplate initiation of thrombolytic therapy immediately.

During the CORE scan, the heart should also be assessed to evaluate global contractility and estimate the ejection fraction. This information can be very useful in guiding fluid resuscitation and titrating doses of vasopressor agents.

To evaluate global function, obtain a parasternal long-axis view of the heart and examine the diameter of the left ventricle during systole and diastole. On global assessment, the heart’s contractility can be generally categorized as either hyperdynamic, normal, mild to moderately decreased, or severely dysfunctional. To obtain a quantitative evaluation of the contractility of the left ventricle, use M-mode to evaluate the fractional shortening of the left ventricular diameter during systole and diastole. Fractional shortening can be calculated using the following formula:

\[
\text{Fractional shortening (\%)} = \left( \frac{\text{EDD} - \text{ESD}}{\text{EDD}} \right) \times 100
\]

where ESD is the end-systolic diameter measured between the ventricular walls just distal to the tips of the mitral valve leaflets, and EDD is the end-diastolic diameter measured between the ventricular walls at the same distance distal to the mitral valve leaflets (Fig. 23).

Studies have shown that a fractional shortening of 30% to 45% correlates with a normal ejection fraction. Note that an M-mode tracing in a normal heart will show the left ventricular walls almost touching completely during systole with a high fractional shortening (Fig. 24).
In a poorly contracting heart, the M-mode tracing demonstrates wide systolic separation between the ventricular walls and a low fractional shortening (Fig. 25). Remember that estimating fractional shortening is a quick and easy way to estimate systolic function at the bedside, and should be used in conjunction with the entire clinical picture.

Other ways to assess the ventricular contractility include assessing the E-point septal separation (EPSS). To evaluate the EPSS, obtain a parasternal long-axis view of the heart. With normal contractility, the anterior mitral leaflet should touch the septum during diastole. The distance separating the anterior mitral leaflet and the septum can be easily evaluated in M-mode (Fig. 26). With the cursor overlying the distal tip of the anterior mitral leaflet, assess the M-mode tracing for a characteristic pattern of two repeating waves. The taller first wave is the E-wave, which reflects the initial opening of the mitral valve to allow passive filling of the left ventricle. The smaller, second wave is the A-wave, which corresponds to left atrial contraction at the end of diastole.18

As cardiac contractility decreases, EPSS increases. Studies have shown that an EPSS greater than 1 cm correlates with a generally low ejection fraction (Fig. 27).19 Of note, EPSS will not accurately predict ejection fraction in patients with mitral valve...
stenosis, mitral valve regurgitation, aortic regurgitation, or extreme left ventricular hypertrophy.

It is important to realize that there are other ultrasonographic methods available to evaluate cardiac contractility and ejection fraction. Many of these methods require specialized ultrasound software and are more time-intensive than the calculations commonly used in the CORE scan. Time and situation permitting, it is useful to learn and apply these calculations during patient management after interventions for acute resuscitation.

**Fig. 26.** Normal E-point septal separation (EPSS) where the anterior mitral valve touches the septum during diastole. A, left atrial contraction; E, initial opening of mitral valve; IVS, interventricular septum.

**Fig. 27.** Abnormally large EPSS from a patient with dilated cardiomyopathy and decreased ejection fraction.
BEDSIDE AORTA ULTRASONOGRAPHY

As part of the CORE scan, the abdominal aorta is evaluated for the presence of abnormalities that would require immediate intervention, such as an aortic aneurysm or aortic dissection. Using a low-frequency curvilinear transducer, obtain a transverse view of the IVC, aorta, and vertebral body just below the xiphoid process. Identifying all three structures in relation to each other will help prevent misidentification of any one of the structures during the scan (Fig. 28).

Once the aorta has been identified in this view, slide the probe toward the patient’s left and center the aorta in the middle of the ultrasound screen. Scan through the abdominal aorta from the subxiphoid region down through the aortic bifurcation. The normal abdominal aorta diameter varies with age and gender. In general, the infrarenal aorta should measure less than 2.3 cm in males and less than 1.9 cm in females. Evaluate the aorta for the presence of an aneurysm (>3.0 cm in diameter), focal dilation of the distal segment greater than 1.5 times the diameter of the proximal segment, lack of normal tapering distally, or the presence of any intraluminal thrombus (Fig. 29). Use gentle pressure and compression to help displace any bowel gas obstructing the view of the aorta, and obtain measurements of the aorta from outer wall to outer wall. If the aorta cannot be adequately visualized from the anterior approach, a longitudinal view of the aorta can be obtained using the liver as a window from the lateral approach (Fig. 30).

The aorta should also be evaluated for any sonographic signs of dissection. Note that most abdominal aortic dissections are usually an extension of a thoracic aortic dissection. On ultrasonography, the presence of a hyperchoic intimal flap will be seen with an acute aortic dissection (Fig. 31).

If an abdominal aortic aneurysm or dissection is visualized, and the patient’s clinical picture is concerning for sequelae from either of these conditions, resuscitation measures should be initiated immediately and the patient should undergo emergent intervention.

BEDSIDE IVC ULTRASONOGRAPHY

After the aorta has been evaluated, the IVC should be assessed to determine the status of the patient’s intravascular volume. The absolute diameter of the IVC provides an estimation of the patient’s central venous pressure. Sonographic imaging of the IVC can be obtained via the anterior view (Fig. 32), or via the lateral view using the liver as an acoustic window (Fig. 33). It is important to obtain the best view of the IVC entering into the right atrium of the heart during the evaluation.

![Fig. 28. Transverse view of the IVC, abdominal aorta, and vertebral body (VB).](image)
Fig. 29. Abdominal aortic aneurysm (4 cm in diameter) with intraluminal thrombus. Ao, aorta; IVC, inferior vena cava; VB, vertebral body.

Fig. 30. Evaluation of abdominal aorta using the liver as a window from the lateral approach.

Fig. 31. Short-axis and long-axis views of an aortic dissection with hyperechoic intimal flap.
The IVC is a highly compliant vessel, whose size varies with changes in total body water and the respiratory cycle. During respiration, negative intrapleural pressure develops, which results in increased venous return to the heart. As flow increases through the IVC, intraluminal pressure decreases and the diameter of the highly compliant IVC decreases. The difference in diameter at inspiration (IVCi) and expiration (IVCe) is referred to as the collapsibility index (also known as the caval index, CI) and is defined as:

\[
\frac{IVCe - IVCi}{IVCe}
\]

The CI has been shown to be higher in patients with shock, and can also be used to determine whether a patient has low central venous pressures. Recently, there has been increased interest in using the IVC diameter to help predict the extent of a patient’s intravascular volume depletion and to help guide resuscitation efforts (Table 2).

It is important to remember that patients who are receiving positive pressure ventilation will have reversal of the IVC dynamics described here. Evaluating volume

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**Fig. 32.** Evaluation of the inferior vena cava (IVC) through the anterior approach.

**Fig. 33.** Evaluation of the inferior vena cava (IVC) through the lateral approach.
Responsiveness with serial measurements of the IVC diameter can help guide resuscitation attempts.

According to recent literature, there are typically 3 common sites of measurement along the IVC (Fig. 34):

1. At the diaphragmatic junction (DJ)
2. Two centimeters distal to the hepatic vein inlet (2HVJ)
3. At the left renal vein junction (LRVJ).

Recent studies have suggested that measurements at 2HVJ provide the most consistent data over the course of the resuscitation attempts.

### BEDSIDE EVALUATION FOR INTRAPERITONEAL FREE FLUID

Part of the CORE scan requires evaluation of the abdomen for the presence of intraperitoneal free fluid. The three main views that are recommended include evaluation of

<table>
<thead>
<tr>
<th>IVC Diameter (mm)</th>
<th>% of Inspiratory Collapse</th>
<th>Estimated RA Pressure (cm H₂O)</th>
<th>Clinical Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;15</td>
<td>100</td>
<td>0–5</td>
<td>Hypovolemic or distributive shock</td>
</tr>
<tr>
<td>15–25</td>
<td>&gt;50</td>
<td>5–10</td>
<td>Shock</td>
</tr>
<tr>
<td>15–25</td>
<td>&lt;50</td>
<td>11–15</td>
<td>Cardiogenic or obstructive shock</td>
</tr>
<tr>
<td>&gt;25</td>
<td>&lt;50</td>
<td>16–20</td>
<td>Cardiogenic or obstructive shock</td>
</tr>
<tr>
<td>&gt;25</td>
<td>0</td>
<td>&gt;20</td>
<td>Right-sided heart failure, massive PE, ARDS, pulmonary HTN, etc</td>
</tr>
</tbody>
</table>

**Abbreviations:** ARDS, acute respiratory distress syndrome; HTN, hypertension; IVC, inferior vena cava; PE, pulmonary embolism; RA, right atrium.

![Fig. 34. Sites to measure IVC diameter and caval index. 2HVJ, 2 cm distal to hepatic vein inlet; DJ, diaphragmatic junction; LRVJ, left renal vein junction.](image)
the right upper quadrant and the hepatorenal fossa, the left upper quadrant and the splenorenal fossa, and the suprapubic region to assess the retrovesicular space. In most situations, a quick assessment of the right upper quadrant should provide enough information to determine whether there is any intraperitoneal free fluid present. This portion of the body is the most dependent when a patient is lying supine. If the patient is sitting upright or if the head of the bed is elevated, the pelvis will be the most dependent portion where fluid will accumulate.

If the patient has intraperitoneal free fluid present, a dark anechoic stripe will be seen between the liver and the right kidney (Fig. 35), between the spleen and the left kidney (Fig. 36), or posterior to the bladder (Fig. 37).

In most circumstances, intraperitoneal free fluid accumulates as a result of trauma, although it can also be seen with rupture of an abdominal aortic aneurysm, rupture of an ectopic pregnancy, hemorrhage from an adnexal cyst or mass, spontaneous rupture or hemorrhage from a large hemangioma or neoplastic mass, or large viscus perforation. It is important to remember that it is difficult to distinguish between a small amount of ascites and intraperitoneal hemorrhage on bedside ultrasonography. Clinical correlation is required to determine the best approach to resuscitation if intraperitoneal hemorrhage is suspected based on the CORE scan. Serial scans are useful to determine whether the amount of intraperitoneal fluid is increasing during resuscitation attempts, and to help guide definitive intervention options.

**BEDSIDE VASCULAR ULTRASONOGRAPHY**

The final part of the CORE scan is to perform bedside ultrasonography to evaluate for the presence of deep venous thrombosis (DVT). The majority of hemodynamically significant pulmonary emboli arise from DVTs from the lower extremities. The venous ultrasonography portion of the CORE scan focuses on the sites where most DVTs are likely to form: the common femoral vein, the proximal superficial femoral vein, and the popliteal vein.

On ultrasonography, veins will appear as oval-shaped hypoechoic structures running alongside round, thicker-walled arteries. Color or pulse-wave Doppler can be used to distinguish veins from adjacent arteries (Fig. 38).

Normal veins should collapse completely when pressure is applied over them with the ultrasound transducer (Fig. 39). If the vein does not compress, there may be an

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Fig. 35. Free fluid (FF) in the hepatorenal space or Morison’s pouch.
Fig. 36. Free fluid (FF) in the splenorenal space and around the spleen.

Fig. 37. Free fluid in the retrovesicular space of the pelvis.

Fig. 38. Normal vein and normal artery with pulse-wave Doppler.
Fig. 39. Normal vein collapsing under transducer compression. FA, femoral artery; FV, femoral vein.

Fig. 40. Hyperechoic clot in the common femoral vein (CFV) and greater saphenous vein (GSV). CFA, common femoral artery.

Fig. 41. Hyperechoic clot in the proximal superficial femoral vein (FV). FA, femoral artery.
intraluminal clot preventing the edges from opposing one another. Acute clots may not be easily visible on ultrasonography, as they are of the same echogenicity as the surrounding venous blood. As clot ages, it becomes more hyperechoic, and can be easily visualized in the lumen of the target vessel (Fig. 40).

Fig. 42. Longitudinal view of a hyperechoic clot in the femoral vein (arrows indicate clot burden).

Box 1
The CORE scan: concentrated overview of resuscitative efforts

1. Is the endotracheal tube in the trachea?
2. Are both lungs being ventilated?
3. Is there a tension pneumothorax that needs to be treated?
4. Is there a pleural effusion or hemothorax that needs to be addressed?
5. Does the patient still have cardiac activity?
6. Does the patient have a pericardial effusion and cardiac tamponade?
7. Is the right ventricle acutely dilated from a large pulmonary embolus?
8. Does the patient have the McConnell sign?
9. How is the heart contracting?
10. What is the estimated ejection fraction of the heart?
11. Does the patient have a symptomatic abdominal aortic aneurysm?
12. What is the intravascular volume status based on evaluation of the inferior vena cava?
13. Is the patient’s inferior vena cava responding to intravascular volume replacement?
14. Does the patient have intraperitoneal free fluid?
15. Does the patient have a deep venous thrombosis?
Using ultrasonography, the common femoral vein, proximal superficial femoral vein, and popliteal veins can be evaluated rapidly to determine whether an intraluminal clot is present (Fig. 41). Once an intraluminal clot has been visualized, a longitudinal view of the affected vessel can be assessed to determine the extent of the clot (Fig. 42).

If a DVT is visualized during the CORE scan, appropriate anticoagulation should be initiated immediately, and the possibility of a large, downstream, pulmonary embolism should be considered as the cause of the patient’s hemodynamic compromise.

SUMMARY

The CORE scan should be used during the evaluation and assessment of patients who present with acute, undifferentiated clinical decompensation. The targeted sonographic views of the CORE scan can be used to diagnose potentially reversible causes of cardiopulmonary and vascular compromise. During the CORE scan, the overall clinical picture will determine the order in which the individual scans are performed. When used in conjunction with clinical findings, the CORE scan can improve diagnostic accuracy and can help guide resuscitative efforts (Box 1).

REFERENCES


