Chapter 2
Extended Focused Assessment with Sonography for Trauma

Ultrasound has revolutionized our ability to rapidly and noninvasively assess for life-threatening injuries requiring operative intervention in patients who have sustained blunt or penetrating trauma. The Extended Focused Assessment with Sonography for Trauma, or the EFAST exam, allows physicians to look inside the abdomen to assess for hemorrhage, the heart for pericardial effusion or tamponade, and the lungs for pneumo- or hemothorax. In an unstable trauma patient, the EFAST exam will help determine proper disposition including immediate operative intervention vs. further workup such as with computed tomography imaging. This chapter will review indications for performing an EFAST exam, basic anatomy, image acquisition, normal ultrasound anatomy, and interpretation of EFAST pathology.

Clinical Application and Indications

- Blunt trauma
- Penetrating trauma
- Unexplained hypotension or alerted mental status

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Normal EFAST Anatomy

- The basic EFAST exam evaluates the abdomen for free intraperitoneal fluid, the heart for pericardial fluid, and the lungs for pneumothorax or hemothorax.
- Right Upper Quadrant (RUQ).
  - Visualize the liver and kidney looking for the potential space between the two called the hepatorenal recess.
  - The diaphragm is seen at the superior edge of the liver as a hyperechoic curved stripe.
  - Lower right lung base will be located above the diaphragm.
- Left Upper Quadrant (LUQ).
  - Visualize the spleen and left kidney with the potential space between the two organs called the splenorenal recess.
  - The diaphragm can be seen at the superior edge of the spleen as a hyperechoic curved stripe.
  - Lower left lung base will be located above the diaphragm.
- Pelvis.
  - Visualize the bladder which will appear as a hypoechoic collection of fluid surrounded by a well-defined echogenic border.
  - To the right and left of the bladder will be a paracolic gutter.
  - Uterus or prostate can be seen posterior to the bladder.
- Subxiphoid.
  - Visualize the heart, pericardial sac, and potential space between the heart and pericardium.
  - The liver will be seen anterior to the heart.
  - Posterior to the liver will be the right ventricle and right atrium.

  - The most posterior structures will be the left ventricle and left atrium.
  - Please see the cardiac chapter for more detailed cardiac anatomy.

- Lung Apices.

  - The lungs sit within the thorax encaged by the ribs and muscular chest wall.
  - Each lung is surrounded by a visceral pleura and parietal pleura with a potential space between the two.

    The pleural line will appear as a hyperechoic horizontal line between two rib spaces.

  - Please see the thoracic chapter for more detailed lung anatomy.

- Inferior Vena Cava.

  - The inferior vena cava (IVC) is the largest vein in the human body.
  - Delivers deoxygenated blood back to the heart from the body inferior to the thorax.
  - The IVC will be seen posterior to the liver entering the right atrium.
  - The IVC normally collapses with inspiration and dilates with expiration.

- Free intraperitoneal fluid or blood accumulates within dependent areas of the abdomen including:

  - Hepatorenal recess between the liver and kidney within the RUQ

    This space is also known as Morrison's pouch.

  - Splenorenal recess between the spleen and kidney within the LUQ
  - Left subphrenic space between the diaphragm and spleen
  - Paracolic gutters within the pelvis
  - Rectovesical pouch

    Most dependent area in the supine male

  - Rectouterine pouch

    Also known as the pouch of Douglas
    Most dependent area in the supine female

- Fluid can accumulate around the heart, within the pericardium.
- Fluid can accumulate within the pleural cavity.

Image Acquisition

1. Transducer Selection
   (a) Curvilinear
   (b) Phased array
2. Patient Position
   (a) The patient should be lying supine.
   (b) Can also place patient in Trendelenburg or reverse Trendelenburg to increase the dependency of the fluid.
3. Standard Exam Views
   (a) Right upper quadrant
   - Place the transducer over the patient's right flank between mid-axillary and anterior axillary line with the transducer marker directed toward the patient's head.
     - Morrison's pouch is usually best imaged between rib 8 and rib 11.
     - Figure 2.1—Transducer placement RUQ.
     - Figure 2.2—RUQ normal EFAST.
     - Video 2.1—RUQ normal EFAST.
   - When scanning through the liver-renal interface, be sure to image the tip of the left side of the liver as this is where blood or fluid will accumulate first in a supine patient [1].
     - Figure 2.3—Liver tip
     - Video 2.2—EFAST liver tip

Figure 2.1 Transducer placement RUQ: Place the transducer over the patient's right flank between the mid-axillary and anterior axillary line with the transducer marker directed toward the patient's head

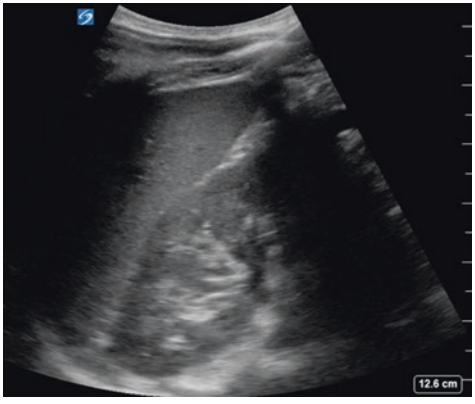

Figure 2.2 RUQ normal EFAST: Normal RUQ EFAST showing no free fluid. Imaging should include the tip of the liver, area between the liver and right kidney, and the diaphragm above the liver

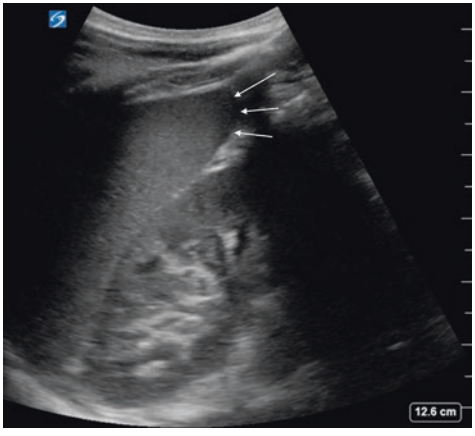

Figure 2.3 EFAST liver tip: RUQ view demonstrating the liver tip above the right kidney. Hemoperitoneum can be detected first around the liver tip; therefore, it is important to image this specific area of the RUQ

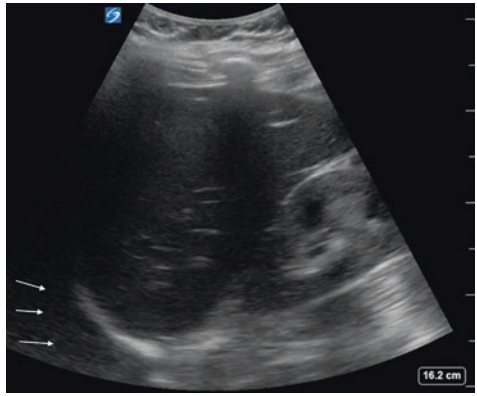

FIGURE 2.4 RUQ EFAST view with hemithorax: Evaluation of the RUQ should include the right hemithorax, visualized above the liver and hyperechoic diaphragm

- Scan through the area including the inferior right hemithorax located above the diaphragm.
  - Figure 2.4—RUQ EFAST view with hemithorax

(b) Left upper quadrant

- Place the transducer over the patient's left flank between the mid and posterior axillary line near the 10th rib space with the marker pointed toward the patient's head.
  - Figure 2.5—Transducer placement LUQ
  - Figure 2.6—LUQ standard view
  - Video 2.3—LUQ standard view
- There is also a potential space located between the spleen and diaphragm; therefore, it is important to image above the spleen.
  - Figure 2.7—LUQ above spleen view
- Scan through the area including the left hemithorax located above the diaphragm.
  - Figure 2.8—Left hemithorax

FIGURE 2.5 Transducer placement LUQ: Place the transducer over the patient's left flank between the mid-axillary and posterior axillary line near the 10th rib space with the marker pointed toward the patient's head

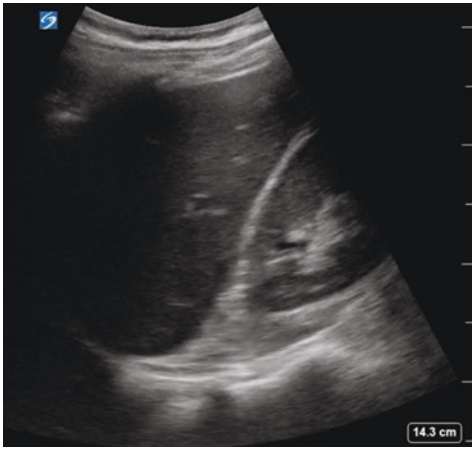

FIGURE 2.6 LUQ standard view: LUQ EFAST view showing no free fluid. Imaging should include the spleen, area between the spleen and left kidney, and views of the diaphragm above the spleen

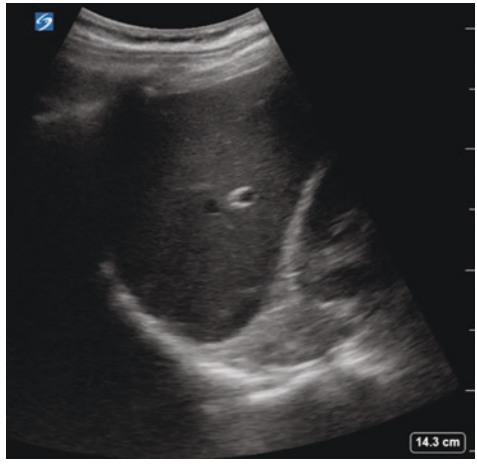

FIGURE 2.7 LUQ EFAST imaging above the spleen: Free fluid will typically accumulate above the spleen first in the LUQ making it important to always image this area

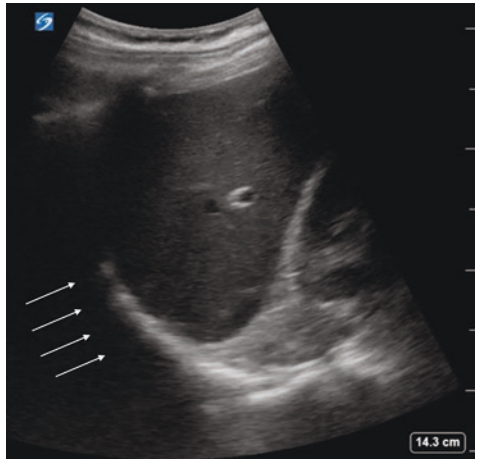

FIGURE 2.8 LUQ EFAST view with left hemithorax: Evaluation of the LUQ should include the left hemithorax, visualized above the spleen and hyperechoic diaphragm

(c) Pelvis

- Place the transducer superior to the pubic bone angled inferiorly with the transducer marker pointed toward the patient's right in the transverse plane.
  - Figure 2.9—Transducer placement pelvis, transverse

FIGURE 2.9 Transducer placement pelvis, transverse: Place the transducer superior to the pubic bone angled inferiorly with the transducer marker pointed toward the patient's right in the transverse plane

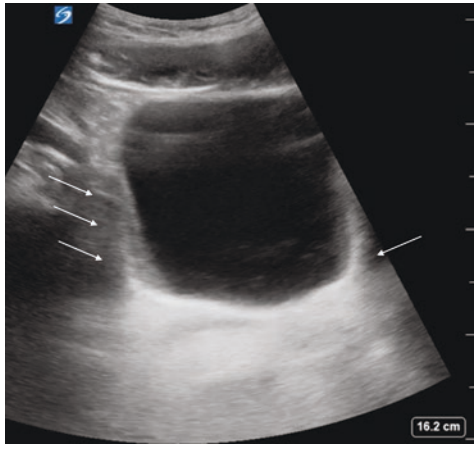

FIG 2.10 Paracolic gutters in transverse: Normal pelvis and bladder EFAST view in a transverse plane. Note bilateral paracolic gutters on each side of the bladder

- Scan through from superior to inferior to visualize the paracolic gutters and area posterior to the bladder.
  - Figure 2.10—Paracolic gutters in transverse
  - Video 2.4—Paracolic gutters in transverse

- Rotate the transducer 90° clockwise to image the pelvis in sagittal plane with the transducer marker pointed to patient's head.
  - Figure 2.11—Transducer placement bladder in sagittal
  - Figure 2.12—Sagittal view of the pelvis
  - Video 2.5—Sagittal view of the pelvis
- Scan through by fanning from right to left.

(d) Subxiphoid

- Place the transducer inferior to the xiphoid process with the marker oriented toward the patient's right.
  - EFAST should be completed in abdominal mode on the ultrasound machine; however, if in cardiac mode, to image the heart, be sure to hold the transducer with the marker pointed toward the patient's left.

FIGURE 2.11 Transducer placement bladder in sagittal: From a transverse position, rotate the transducer 90° clockwise to image the pelvis in sagittal plane with the transducer marker pointed to patient's head

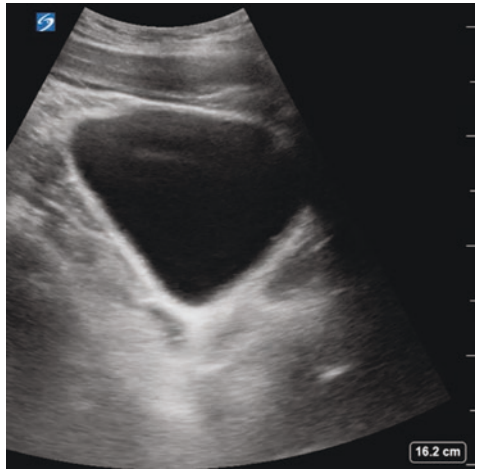

Fig 2.12 Sagittal view of bladder: Normal pelvis and bladder EFAST view in a sagittal plane

- Place operator's hand on top of the transducer, use a moderate amount of force to press the transducer into the patient's abdomen, and angle the transducer superior and leftward toward the left shoulder.
  - Figure 2.13—Subxiphoid EFAST transducer placement
- Adjust depth to adequately visualize the entire heart.
- Figure 2.14—Subxiphoid EFAST view
- Video 2.6—Subxiphoid EFAST view

(e) Bilateral lung apices

- Can use curvilinear, linear, or phased array transducer.
- Place the transducer on the anterior chest in a sagittal orientation with the marker pointed toward the patient's head over the 2nd intercostal space.
  - Figure 2.15—Transducer placement lungs
  - Figure 2.16—Lung view EFAST
  - Video 2.7—Lung sliding
- Evaluate for lung sliding, which occurs due to the visceral pleura sliding against the parietal pleura.

Fig 2.13 Subxiphoid EFAST transducer placement: Place the transducer inferior to the xiphoid process with the marker oriented toward the patient's right. Place operator's hand on top of the transducer, use a moderate amount of force to press the transducer into the patient's abdomen, and angle the transducer superior and leftward toward the left shoulder

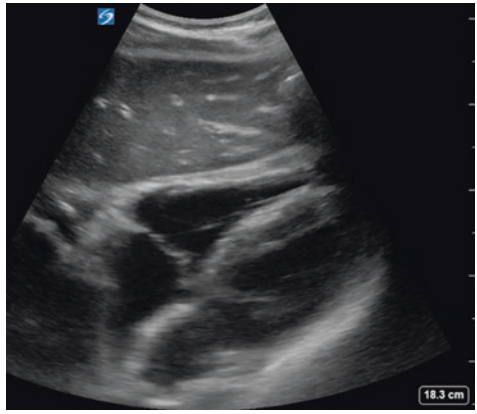

Figure 2.14 Subxiphoid EFAST view: Normal EFAST demonstrating a subxiphoid view of the heart. The liver is used as the acoustic window to view cardiac structures and pericardium. The right heart sits closest to the liver

Fig 2.15 Transducer placement lungs: Place the transducer on the anterior chest in a sagittal orientation with the marker pointed toward the patient's head over the 2nd intercostal space

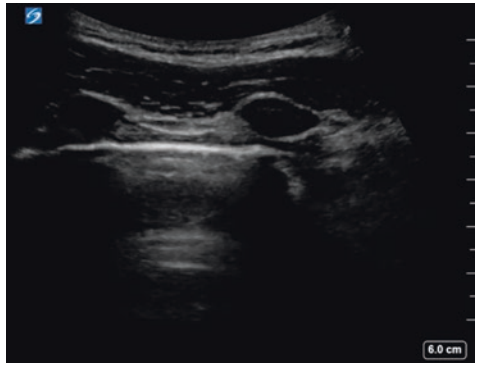

Figure 2.16 Lung view EFAST: Normal EFAST demonstrating lung sliding. Note two anechoic ribs with posterior acoustic shadowing and the hyperechoic pleural line between them

- Lung sliding appears as horizontal movement of two thin hyperechoic lines in a to-and-fro movement.
- Decrease the gain to help visualize the pleura.
- Use M-mode to confirm findings or if unable to determine the presence of lung sliding.
  - Place the M-mode line between two ribs, so it crosses perpendicularly over the pleura.
  - Identify "seashore sign" with normal lung sliding.

    Horizontal lines represent the static chest wall [2].
    Granular pattern represents movement of the lung beyond the pleural line [2].
    Figure 2.17—M-mode spike position.
    Figure 2.18—Normal sliding lung M-mode.

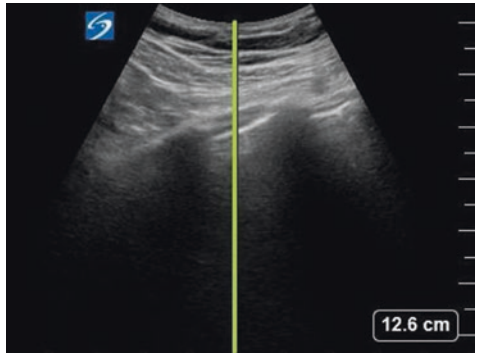

FIGURE 2.17 M-mode spike position: The M-mode spike should be placed between the two rib shadows overlying the hyperechoic pleural line

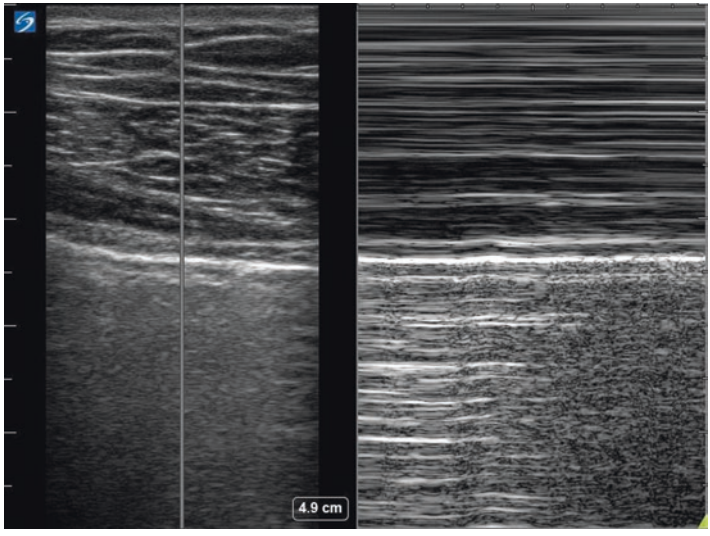

FIGURE 2.18 Normal sliding lung M-mode: M-mode ultrasonography of a normal lung demonstrates the static chest wall in the top half of image and movement of the lungs in the bottom half consistent with normal respiration. Sometimes referred to as "seashore" sign

(f) Inferior vena cava

- Place the transducer inferior to the xiphoid process, slightly to the right of midline, with the marker oriented toward the patient's head.
- Figure 2.19—Transducer placement IVC
- Figure 2.20—IVC view
- Video 2.8—IVC view

FIGURE 2.19 Transducer placement IVC: Place the transducer inferior to the xiphoid process, slightly to the right of midline, with the marker oriented toward the patient's head

FIGURE 2.20 IVC view: Normal EFAST view of the IVC as it passes by the liver and drains into the right atrium of the heart

EFAST Pathology

(a) Hemoperitoneum

- Accumulation of blood within the peritoneum.
- Blood will be seen as an anechoic, hypoechoic, or echogenic fluid collection:
  - Between the liver and kidney

    Figure 2.21—Positive EFAST Morrison's pouch
    Video 2.9—Positive EFAST Morrison's pouch

  - Around the liver tip

    Figure 2.22—Positive EFAST liver tip
    Video 2.10—Positive EFAST liver tip

  - Between the spleen and kidney

    Figure 2.23—Positive EFAST LUQ
    Video 2.11—Positive EFAST LUQ

  - Between the spleen and diaphragm

    Figure 2.24—Positive EFAST LUQ above the spleen
    Video 2.12—Positive EFAST LUQ above the spleen

FIGURE 2.21
Positive EFAST Morrison's pouch: Free fluid is located within Morrison's pouch between the liver and right kidney

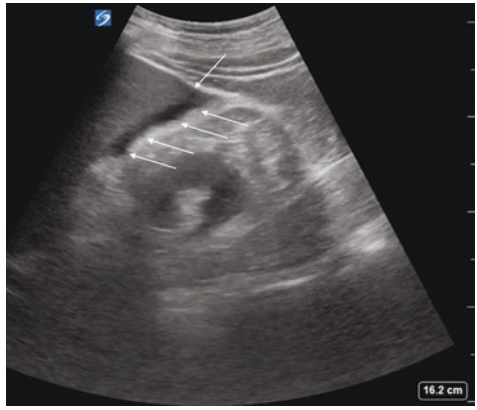

Fig 2.22 Positive EFAST liver tip: Free fluid is seen here surrounding the liver tip

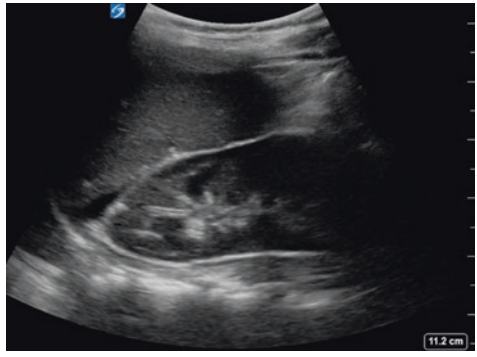

Figure 2.23 Positive EFAST LUQ: Free fluid is seen here between the spleen and left kidney

- Posterior to or on either side of the bladder

  Figure 2.25—Positive EFAST bladder transverse
  Video 2.13—Positive EFAST bladder transverse
  Figure 2.26—Positive EFAST bladder sagittal
  Video 2.14—Positive EFAST bladder sagittal

- Depending on the amount of fluid, can be a large pocket or a small anechoic stripe.

(b) Hemothorax or Pleural Effusion

- Abnormal accumulation of blood or fluid between the two pleural layers

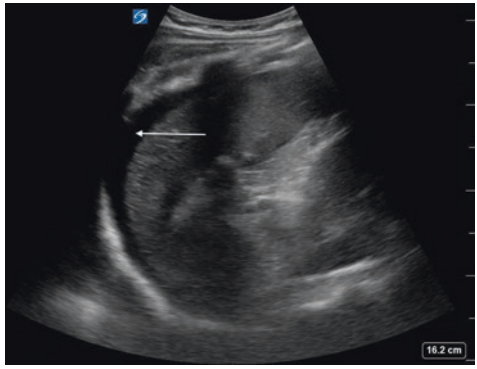

FIGURE 2.24 Positive EFAST LUQ above spleen: Free fluid is located superior to the spleen and inferior to the diaphragm. Fluid will typically accumulate above the spleen first in the LUQ making it important to always image this area

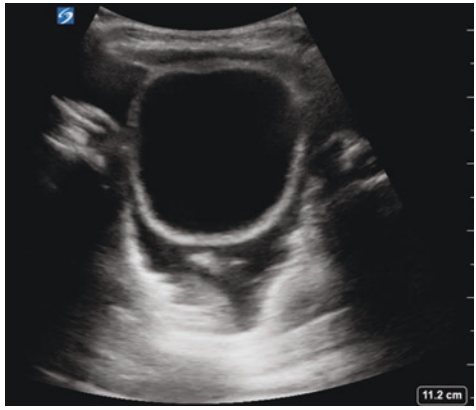

FIGURE 2.25 Positive EFAST bladder transverse: Free fluid is surrounding the bladder in a transverse plane. Note the anechoic fluid posterior to the bladder and in both paracolic gutters

- Anechoic or hypoechoic fluid collected above the diaphragm within the thoracic cavity between the visceral and parietal pleura
  - Can be seen when imaging the right or left upper quadrants
  - Will accumulate posteriorly if the patient is supine and inferiorly between the diaphragm and lung if the patient is upright

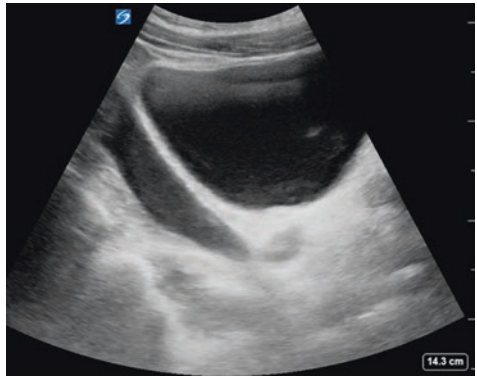

FIGURE 2.26
Positive EFAST bladder sagittal: Free fluid is found around the bladder in the sagittal plane

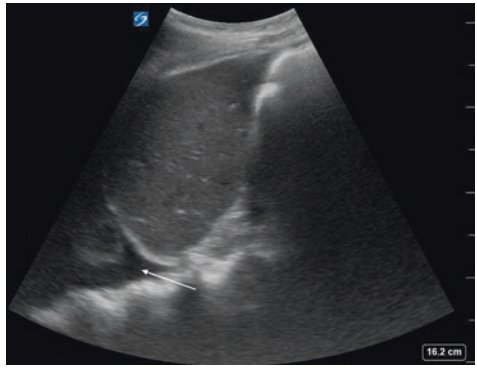

FIGURE 2.27
Positive pleural fluid above the diaphragm: A small pleural effusion (*arrow*) is noted above the diaphragm

  - Figure 2.27—Pleural effusion
  - Video 2.15—Pleural effusion
- May see "curtain" or "flag" sign which occurs with the lung slides into the effusion during respirations
  - Figure 2.28—Large pleural effusion with flag sign
  - Video 2.16—Large pleural effusion with flag sign

(c) Pneumothorax

- Caused by separation of the lung pleura away from the chest wall, resulting in a collapsed lung

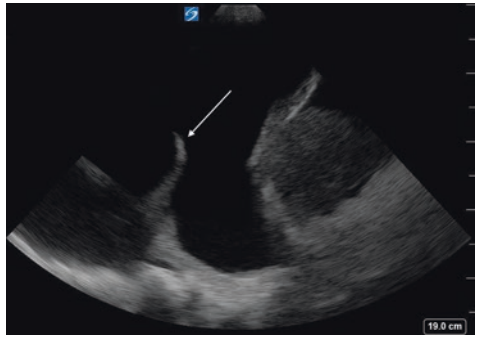

FIGURE 2.28 Large pleura effusion with flag sign: With large pleural effusions, the lung will appear to be floating in the fluid, creating what looks like a flag flapping in the wind (flag sign)

- Absent lung sliding due to the separation of the visceral pleura from the parietal pleura [2]
  - Video 2.17—Absent lung sliding
- If lung sliding is absent, move the transducer superior or inferior to locate the lung point sign.
  - Lung point sign is the transition point between normal lung sliding and a pneumothorax with the absence of lung sliding.
  - This is not always present, especially with a large pneumothorax [2].
  - Lung point sign is 100% specific for pneumothorax [2].
  - Video 2.18—Lung point.
- Use M-mode to confirm the absence of sliding as described above.
  - M-mode will demonstrate no movement of the lungs, which is sometimes referred to as barcode sign due to the horizontal lines seen throughout the entire image [2].
  - Figure 2.29—Barcode sign.

(d) Hemopericardium or Pericardial Effusion

- Accumulation of blood or fluid between the visceral and parietal pericardium surrounding the heart.

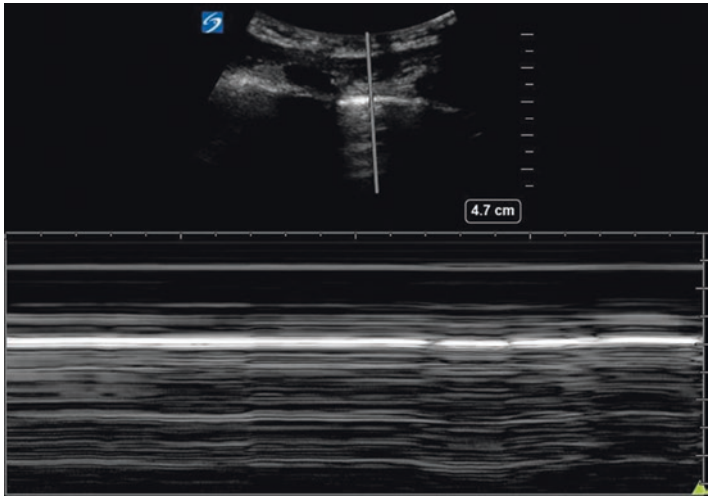

FIGURE 2.29 Barcode sign: M-mode through the pleural line demonstrates no movement as evidenced by the horizontal lines in the bottom half of the image. This is sometimes referred to as "barcode sign" given the similar appearance to retail barcodes

- Appears as a hypoechoic stripe between the heart and brightly echogenic pericardium at the inferior border of the heart, which can be seen next to the liver.
  - Figure 2.30—Pericardial effusion
  - Video 2.19—Pericardial effusion
- The sonographer can distinguish a left pleural effusion from a pericardial effusion by the pattern of fluid.
  - Pericardial fluid will be present posterior to the left ventricular wall and anterior to the descending aorta [3].
  - Left-sided pleural effusion will occur posterior to the left ventricular wall and will not be present anterior to the descending aorta [3].
  - Figure 2.31—Comparing pleural fluid vs. pericardial fluid.

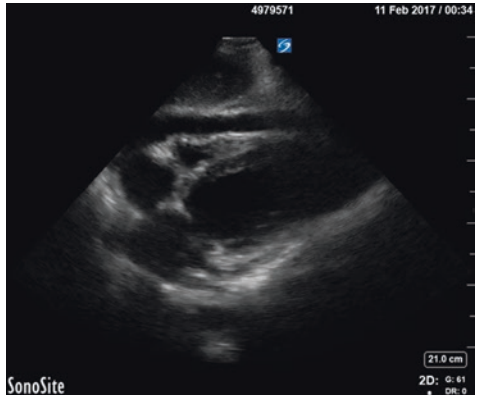

FIGURE 2.30 Pericardial effusion: Anechoic fluid surrounds the right heart indicating a pericardial effusion

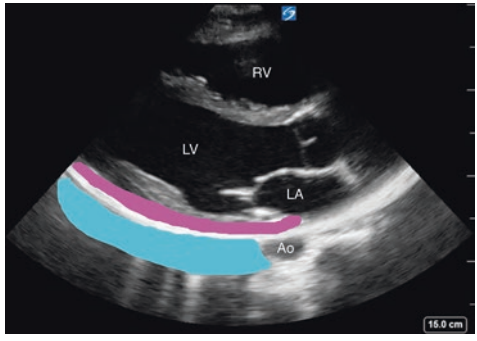

FIGURE 2.31 Comparing pleural fluid and pericardial fluid: In a parasternal long view, pericardial fluid will be present posterior to the left ventricular wall and anterior to the descending aorta. A left-sided pleural effusion will occur posterior to the left ventricular wall and will not be present anterior to the descending aorta

(e) Cardiac Tamponade

- Occurs when fluid within the pericardium generates excessive external pressure, which then impairs the ability for the heart chambers to fill eventually causing hypotension and shock

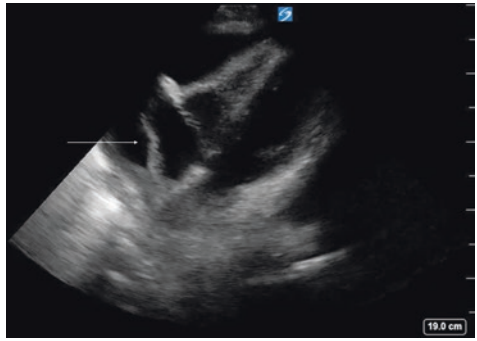

FIGURE 2.32 Right atrial systolic collapse in tamponade: In cardiac tamponade, the pressure within the pericardium exceeds the pressure within the right atrium causing it to collapse during systole

  - Affects the thin-walled right atrium and right ventricle first.
  - Right atrial systolic collapse [3, 4] is the most sensitive sign of tamponade.

    Usually the first echocardiographic sign
    Figure 2.32—Right atrial systolic collapse in tamponade
    Video 2.20—Right atrial systolic collapse in tamponade

  - Right ventricular diastolic collapse [4] is the most specific sign of tamponade [3].

    Figure 2.33—Right ventricle collapse
    Video 2.21—Right ventricle collapse

- Will also see a dilated IVC with minimal collapse [4]
  - Figure 2.34—Plethoric IVC
  - Video 2.22—Plethoric IVC

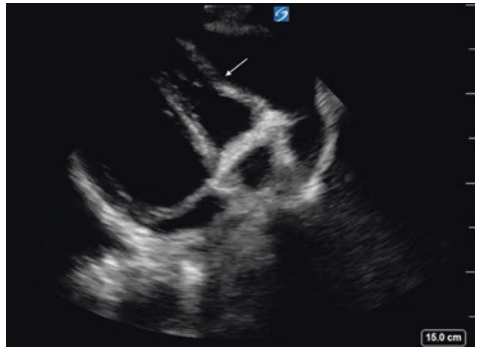

FIGURE 2.33 Right ventricle collapse: In cardiac tamponade, the pressure within the pericardium exceeds the pressure within the right ventricle causing it to collapse during diastole

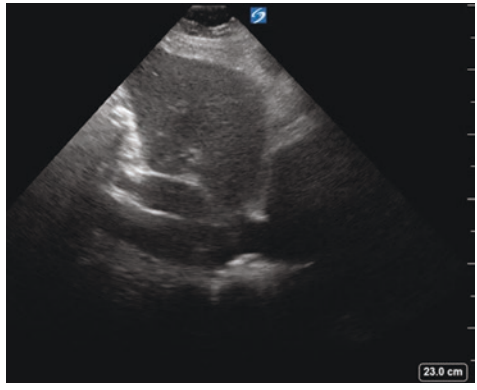

FIGURE 2.34 Plethoric IVC: Here the IVC is visualized passing the liver and draining into the right atrium. Note that the IVC is quite large indicating the IVC is plethoric

Key Points

- To have a positive EFAST, as little as 100 cc of fluid can be detected with ultrasound [1, 5].
- Use EFAST as a serial screening exam; rapidly repeat with any change in patient status.
- Hemoperitoneum can be anechoic or echogenic depending on if clot formation has begun.
  - If presentation following trauma is delayed, blood within the peritoneum will often be clotted and can be missed [6].

- Morrison's pouch is the most sensitive location of identifying hemoperitoneum.
  - In children, fluid will accumulate in the pelvis before the RUQ.
- Fluid will most often accumulate between the diaphragm and spleen first, before splenorenal recess, when there is blood in the LUQ [1].
  - However, blood from a splenic injury will usually accumulate in the RUQ before demonstrating evidence of hemoperitoneum in the LUQ.
- Placing the patient in Trendelenberg and reverse Trendelenberg and waiting about 5 min for fluid to accumulate by gravity will increase the sensitivity of the EFAST exam.
- Ultrasound cannot determine the etiology of the fluid within the abdomen. Fluid that is seen on ultrasound may or may not be blood and may or may not be the result of trauma.
- The sonographer cannot visualize the retroperitoneum using the EFAST exam. Therefore, bleeding from retroperitoneal structures such as the kidneys or aorta will be difficult to assess.
- Use both transverse and sagittal views to examine for intraperitoneal fluid in the pelvis.
- Care must be taken to differentiate between intra-abdominal organs and fluid, such as bowel.
- When evaluating for a pericardial effusion, an epicardial fat pad can be confused with a small pericardial effusion.
  - An epicardial fat pad will be anterior to the right ventricle in the parasternal long view.
  - Can sometimes be distinguished from blood or fluid by a speckled appearance [3].
  - More common in diabetics, obese, elderly, and females [3].

- If unable to visualize the heart adequately in a subxiphoid window, obtain an image using a parasternal long technique (see Chap. 3 for more details).
  - Can also try having the patient take a deep breath in and hold it, which may push the cardiac structures into view
- EFAST exam will be limited by morbid obesity and subcutaneous emphysema.
- EFAST has been shown to have a higher sensitivity than chest X-ray when evaluating for pneumothorax [7].

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