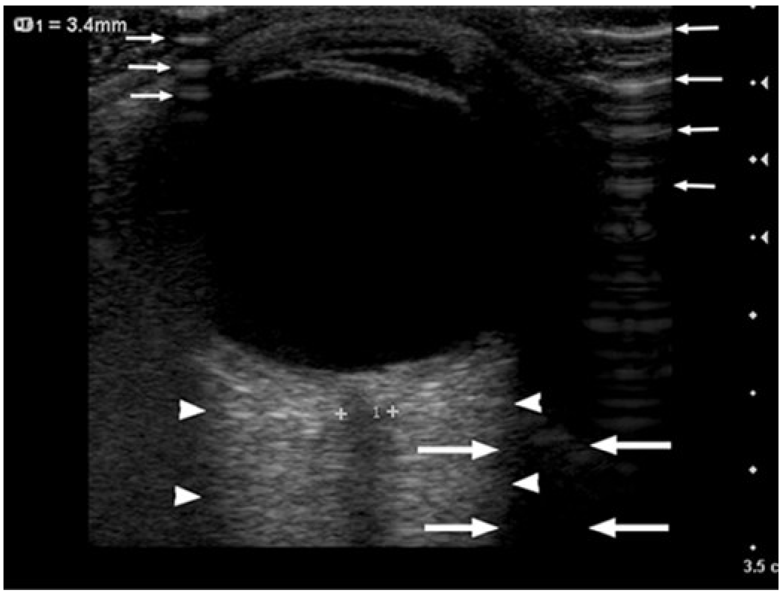
Questions and Answers

II. PHYSICS AND KNOBOLOGY

Q1: Name the three types of artifact indicated by the three types of arrows in this image of an ocular ultrasound.

FIGURE 15-1

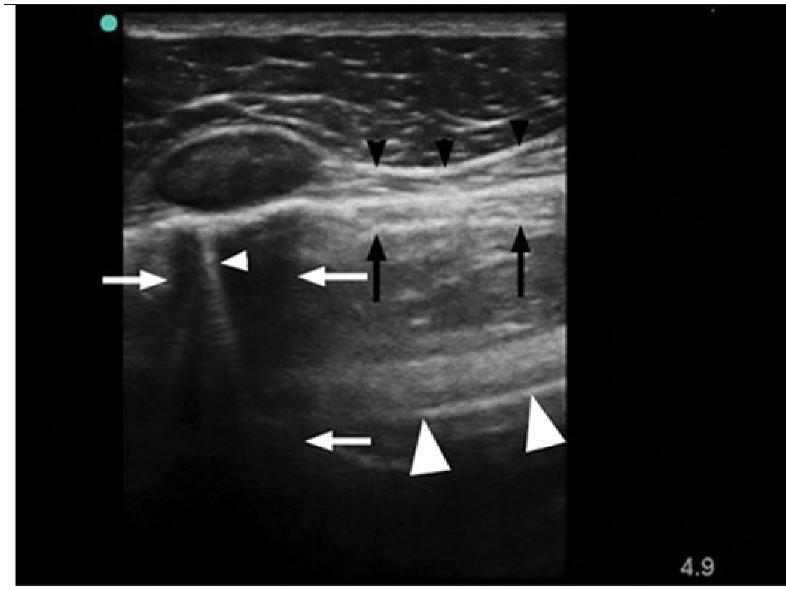


Source: C. M. Baston, C. Moore, E. A. Krebs, A. J. Dean, N. Panebianco: *Pocket Guide to POCUS: Point-of-Care Tips for Point-of-Care Ultrasound,* 1st edition.

Q1 Answer: Reverberation artifacts occur where there are two reflective surfaces that are perpendicular to the direction of the ultrasound beam and parallel to one another. The surface of the transducer itself can act as such a surface, creating reverberation artifacts that appear to arise from the skin, as in this case (small arrows). Behind the globe there is an area of posterior acoustic enhancement, which makes the retro-orbital soft tissues between the arrowheads appear brighter than the same tissue to the left. The left side of the eyeball (right side of screen) appears to be creating an acoustic shadow (larger arrows). If this darker area was continuous from the skin surface it could be attributed to absence of gel in this location, which can also cause shadowing on the image. However, in this case, the anterior soft tissues immediately under the probe appear symmetrical on both sides except where there is interference from reverberation artifact. The diminished echo signal in the "shadow" is due to a combination of factors and is frequently seen with circular structures such as this. The factors include the disadvantageous angle of insonation for structures that are parallel with the beam (leading to a paucity of echoes), and increased absorption of sound in the dense connective tissue walls of the globe.

Q2: Name the three types of artifact indicated by the three types of white arrows in this image of a thoracic ultrasound (bonus points for the type of artifact indicated by the black arrows).

FIGURE 15-2



Source: C. M. Baston, C. Moore, E. A. Krebs, A. J. Dean, N. Panebianco: *Pocket Guide to POCUS: Point-of-Care Tips for Point-of-Care Ultrasound*, 1st edition.

Q2 Answer: Artifacts are used extensively in diagnostic ultrasound to identify both normal and abnormal conditions. This is particularly true of lung ultrasound. The accompanying still image serves as a guide to the artifacts that can be seen at various moments in this clip. Behind the ribs, shadowing can be seen (between the three white arrows). At the lung surface, multiple small reverberation artifacts (small white arrowheads) can be seen throughout the clip. Because they barely reach the bottom of the image, adjusted to the very superficial depth of 4.9 cm, they do not qualify as B-lines (see Chapter 6), but rather are clinically insignificant Z-lines, caused by irregularities on the surface of the visceral pleura. An A-line (also a reverberation artifact: see text) is indicated by the large white arrowheads. There is mirror artifact caused by the plural surface giving rise to the appearance of the superficial fascia of the intercostal muscles (black arrowheads) within the lung parenchyma (black arrows).

Q3: Define the following terms:

- **Zoom**
- **Depth**
- **Gain**
- **TGC**
- **Acoustic shadow**
- **Posterior acoustic enhancement**

Q3 Answer:

Zoom: In cases where greater detail is needed to examine objects at the bottom of the image and further decreases of depth would cause them to disappear, zoom can be used. Decreases in depth increase resolution for the objects that are on the screen. Zoom merely provides digital enlargement, it does not improve true resolution.

Depth adjusts the scale of the entire image. In general, images should be adjusted for minimal depth such that all objects of interest are included in the image and that the deepest of these objects appears just above the bottom of the screen. In other words, the image should not include a great deal of space demonstrating structures deep to those that are of interest. Sonologists often organize their depth according to the "80/20 rule": 80% of the depth for direct visualization of the structures of interest; 20% to prove that there are/are not significant artifacts or other abnormalities deep to the structures of interest.

Gain is the amplification of the electrical signal generated by the returning echoes. As such it is a post-processing adjustment (as opposed to Power, which is the strength of the ultrasound waves generated by the transducer). It adjusts how bright the various structures appear on the ultrasound image.

TGC (time gain compensation) adjusts the gain selectively at different depths.

Acoustic shadowing is caused by structures that absorb and/or reflect ultrasound waves completely. Behind such structures, other objects appear artifactually dark or black.

Posterior acoustic enhancement is caused by structures that transmit ultrasound waves with less than the usual amount of attenuation-typically aqueous structures. As a result, tissues and structures that are behind them appear artifactually bright or sometimes white, on occasion causing abnormal collections of fluid or other pathological conditions to be overlooked.

III. ULTRASOUND-GUIDED PERIPHERAL INTRAVENOUS ACCESS

Q4: Identify the errors being made by the clinician in this image.

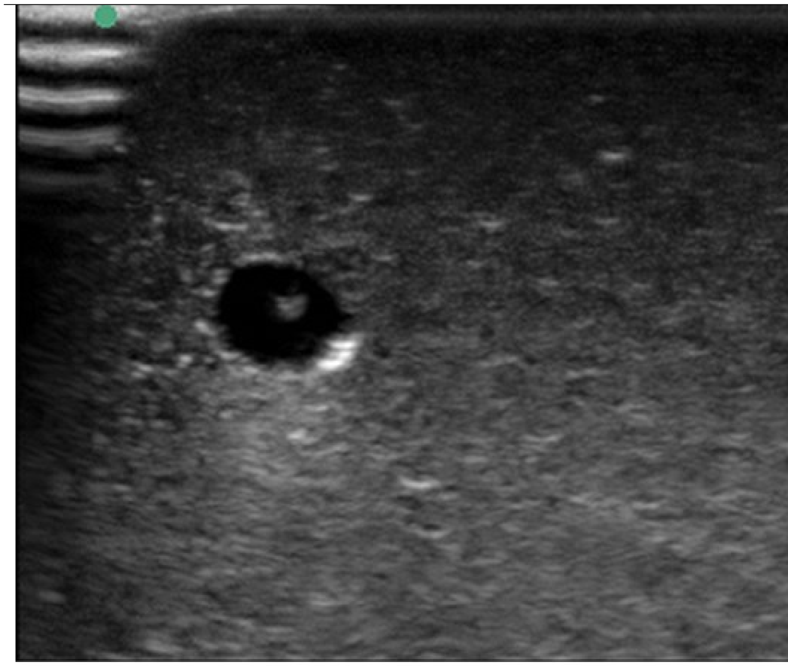
FIGURE 15-3

Source: C. M. Baston, C. Moore, E. A. Krebs, A. J. Dean, N. Panebianco: *Pocket Guide to POCUS: Point-of-Care Tips for Point-of-Care Ultrasound*, 1st edition. Copyright © McGraw-Hill Education. All rights reserved.

Q4 Answer: The operator is bent in an uncomfortable position. She should be seated, ideally on a stool with wheels, to facilitate movement in such a way as to optimize manual dexterity. The screen of the ultrasound machine is not parallel with the scanning plane, making it difficult to conceptualize the necessary corrective movements of the needle. In addition, the location of the machine requires the operator to twist her neck in order to see it. Ideally, the screen of the machine should be close, allowing for visualization of both the patient's arm and the screen with extraocular movement alone. The patient's arm is not supported, and there is no working surface on which to place the necessary equipment and supplies. The probe is at an awkward angle because the patient's arm is rotated internally. The operator is not wearing gloves and there is no protective equipment on the probe.

Q5: Describe the process for determining whether this is an image of the needle tip in the vessel.

FIGURE 15-4



Source: C. M. Baston, C. Moore, E. A. Krebs, A. J. Dean, N. Panebianco:
Pocket Guide to POCUS: Point-of-Care Tips for Point-of-Care Ultrasound, 1st edition.

Q5 Answer: Mistaking the middle of the needle for the needle tip is the most common error in ultrasound-guided venous access. If the procedure in Chapter 3 is followed, the needle tip should never be lost, but if it is, slide the probe away from the skin puncture site until the hyperechoic signal of the needle disappears. Then slowly slide the probe back; the first bright spot to appear will be the needle tip.

Q6: Describe the methods for determining which of these vessels of the arm is an artery and which is a vein.

FIGURE 15-5

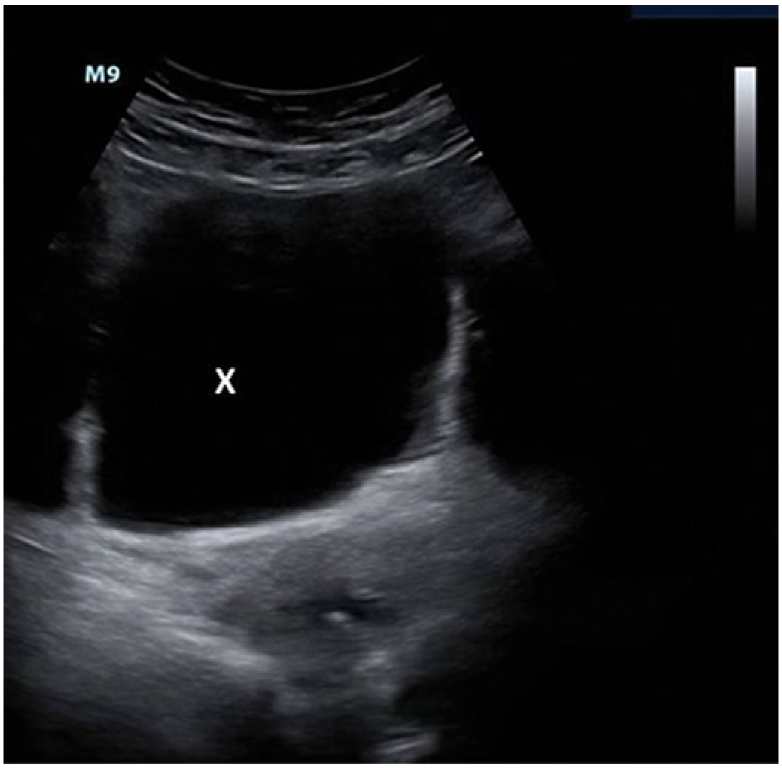
Source: C. M. Baston, C. Moore, E. A. Krebs, A. J. Dean, N. Panebianco:
Pocket Guide to POCUS: Point-of-Care Tips for Point-of-Care Ultrasound, 1st edition.

Q6 Answer: Veins can be distinguished from arteries, as they are easily compressible, have thinner walls, and are less pulsatile and on the basis of anatomic knowledge of the expected location. Nerves are also incompressible, they demonstrate a "honeycomb" internal structure in the transverse plane when the ultrasound beam is perpendicular, and internally anechoic when the incident beam is at a non-perpendicular angle (the property of "anisotropy"). Color and spectral Doppler can also distinguish nerves, veins, and arteries, but require advanced understanding. Remember that red means blood flow is toward the probe, not that the blood is oxygenated.

IV. FOCUSED ASSESSMENT FOR FREE FLUID (FAFF)

Q7: How does one determine whether the fluid in the space marked with an X is free abdominal fluid or fluid contained in a viscera?

FIGURE 15-6



Source: C. M. Baston, C. Moore, E. A. Krebs, A. J. Dean, N. Panebianco: *Pocket Guide to POCUS: Point-of-Care Tips for Point-of-Care Ultrasound,* 1st edition.

Q7 Answer: The X is labeling the bladder. Fluid contained in a viscera has rounded interfaces with other tissues, while free fluid forms sharp (acute) angles. Small volumes of FF in the pelvis tend to gather posterior to the uterus in the rectouterine space (AKA Pouch of Douglas). The uterus is the oval soft tissue structure seen in this image behind the bladder.

Q8: What are the potential spaces that can be interrogated in the right-upper-quadrant (RUQ) window? Which, if any, are not visualized in this image?

FIGURE 15-7

Source: C. M. Baston, C. Moore, E. A. Krebs, A. J. Dean, N. Panebianco:
Pocket Guide to POCUS: Point-of-Care Tips for Point-of-Care Ultrasound, 1st edition.

Q8 Answer: In general, all spaces should be visualized as a continuous video. As a still image, the inferior pole of the kidney is incompletely evaluated in this image. Morison's pouch, the pleural space, and the subphrenic space are well visualized. The absence of pleural fluid is demonstrated by the presence of the mirror artifact.

Q9: Name the four windows to evaluate for free fluid. Which is the most sensitive?

Q9 Answer:

1. Right upper quadrant (RUQ) (Morison's pouch) is the most sensitive.
2. Left upper quadrant (LUQ)
3. Subxiphoid
4. Pelvic or suprapubic

V. ULTRASOUND-GUIDED PARACENTESIS

Q10: Prior to performing a paracentesis at this location, what other views or measurements should be acquired?

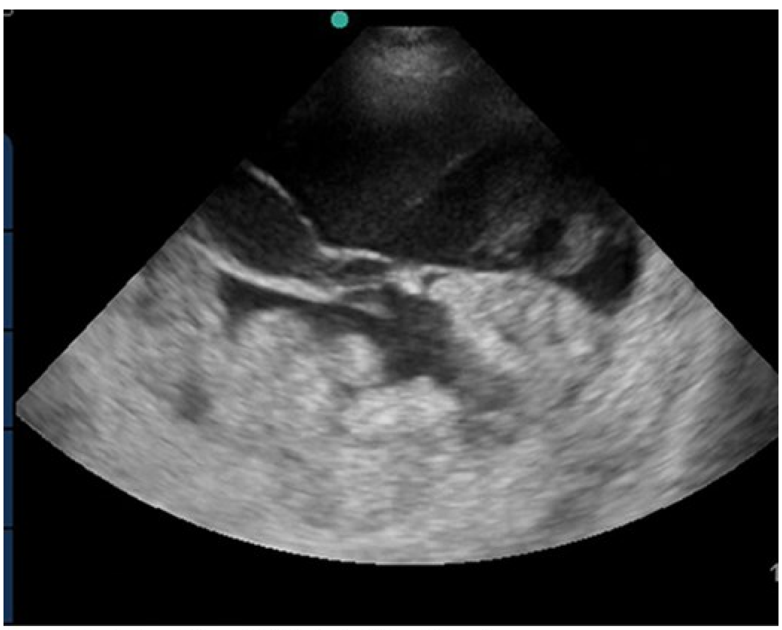
FIGURE 15-8

Source: C. M. Baston, C. Moore, E. A. Krebs, A. J. Dean, N. Panebianco:
Pocket Guide to POCUS: Point-of-Care Tips for Point-of-Care Ultrasound, 1st edition.

Q10 Answer: Always perform a check for vascular structures using a high-frequency probe. This can include inferior epigastric vessels (posterior to muscle layers within the peritoneal fat layer) as well as dilated veins due to portal hypertension (external to muscle layers). Measure the depth of the soft tissue prior to performing the procedure, as well as the depth of fluid, to avoid having the needle poke any structures that should not be poked.

Q11: What can be concluded about the peritoneal fluid in this image?

FIGURE 15-9



Source: C. M. Baston, C. Moore, E. A. Krebs, A. J. Dean, N. Panebianco:
Pocket Guide to POCUS: Point-of-Care Tips for Point-of-Care Ultrasound, 1st edition.

Q11 Answer: The hyperechoic structures seen are loculations, which appear in malignant, infected, or bloody fluid. This suggests an exudative process prior to even getting a sample.

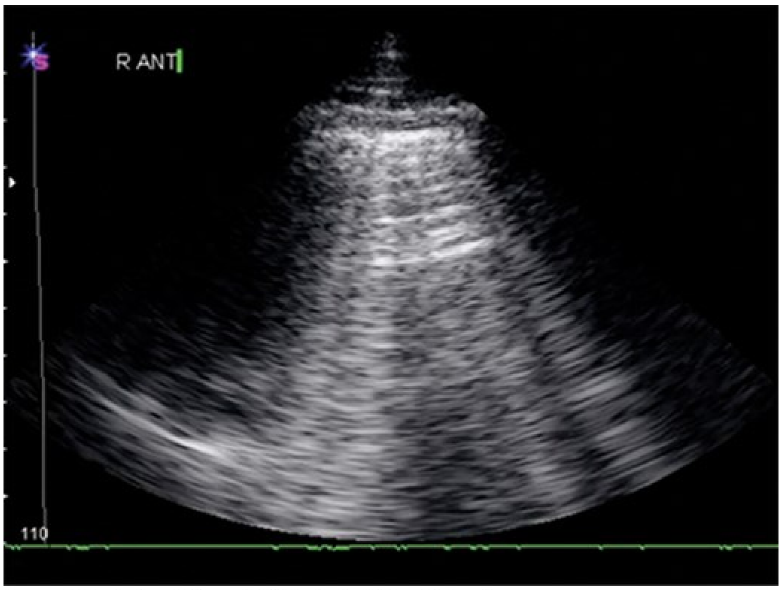
Q12: What error is most likely if fluid is not encountered by the needle at the depth expected based on the preprocedural ultrasound?

Q12 Answer: The most common error made with this procedure is to mistakenly advance the needle along a different angle than the one used when initially evaluating the space with ultrasound. This will result in a longer distance needed to travel and can potentially lead to complications as the needle will now be passing through structures not initially visualized on the ultrasound.

VI. LUNG ULTRASOUND: PARENCHYMA AND LUNG SLIDING

Q13: What finding rules out pneumothorax at this site in this ultrasound image, and what other findings may rule out pneumothorax?

FIGURE 15-10

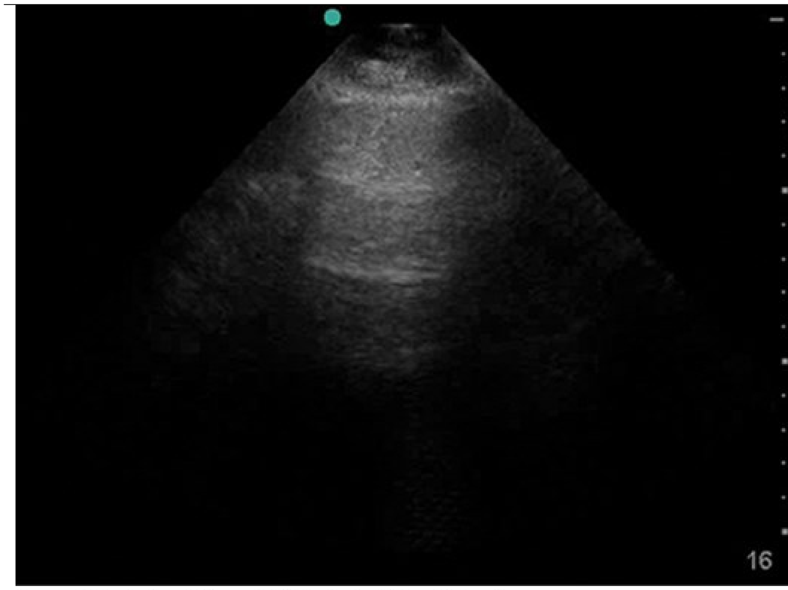


Source: C. M. Baston, C. Moore, E. A. Krebs, A. J. Dean, N. Panebianco: *Pocket Guide to POCUS: Point-of-Care Tips for Point-of-Care Ultrasound,* 1st edition.

Q13 Answer: The vertical artifacts in this image (B-lines) are generated when the ultrasound waves reverberate within the first alveolar-interstitial space. Air in between the layer of pleura (pneumothorax) prevents the formation of B-line artifacts. Other findings that rule out pneumothorax (at the location of the probe) include lung sliding, lung pulse, and Z-lines.

Q14: What pathological conditions could cause shortness of breath in a patient with this finding on lung ultrasound?

FIGURE 15-11



Source: C. M. Baston, C. Moore, E. A. Krebs, A. J. Dean, N. Panebianco:
Pocket Guide to POCUS: Point-of-Care Tips for Point-of-Care Ultrasound, 1st edition.

Q14 Answer: The horizontal lines seen in the image are A-lines (see text for more details). These reverberations be-tween the pleura and surface of the probe are found in normal lungs but are also found in pneumothorax (although without lung sliding), chronic obstructive pulmonary disease (COPD), asthma, pulmonary embolus (PE), and any pulmonary process in which the pathology doesn't reach the lung periphery.

Q15: If lung sliding is not easily identified, what steps can be taken on the ultrasound machine to make it easier to assess?

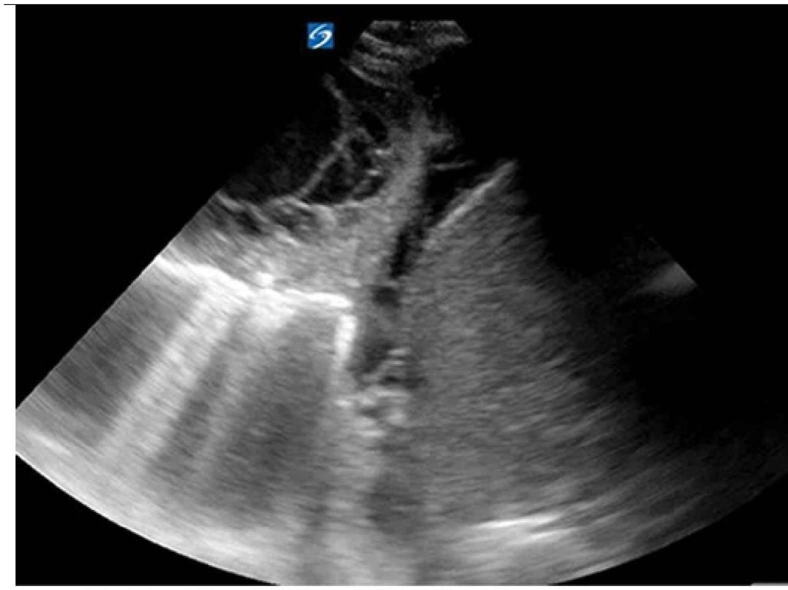
Q15 Answer:

1. Change to the linear (high-frequency) transducer.
2. Decrease the depth until the pleura is at the center of the screen, or if available, the focal zone is at the level of the pleura.
3. Decrease the gain until the pleura is the only bright line visible.
4. Use M-mode to identify lung sliding.

VII. ULTRASOUND-GUIDED THORACENTESIS

Q16: What can be concluded about the pleural fluid in this ultrasound image?

FIGURE 15-12

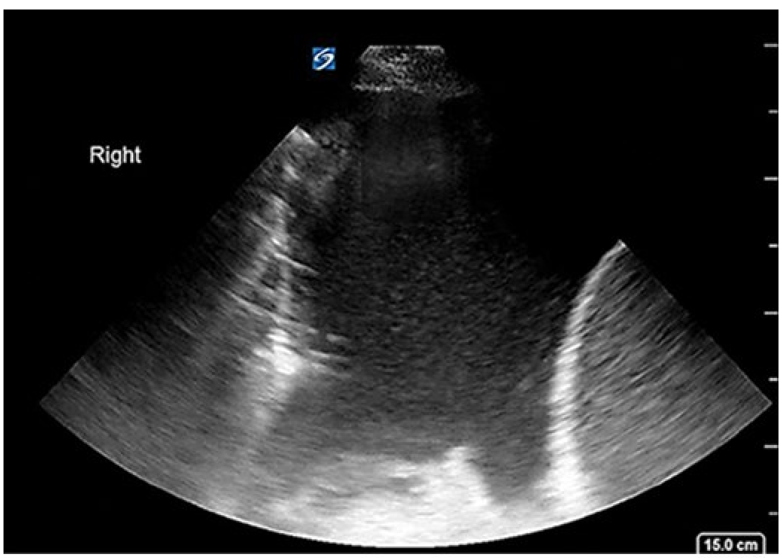


Source: C. M. Baston, C. Moore, E. A. Krebs, A. J. Dean, N. Panebianco:
Pocket Guide to POCUS: Point-of-Care Tips for Point-of-Care Ultrasound, 1st edition.

Q16 Answer: The thin bright white lines traversing the fluid and connecting the consolidated lung to the parietal pleura across the anechoic effusion are septations. Early in the course of empyema, the pleural fluid will have diffuse internal echoes caused by the pus, which may be seen to swirl with respiration, and/or demonstrate fluid-fluid levels. In this case, the image is of empyema and these hyperechoic structures are from the purulent fluid collection. They strongly suggest exudative effusions.

Q17: What measurements should be made on this ultrasound image prior to proceeding with the procedure?

FIGURE 15-13



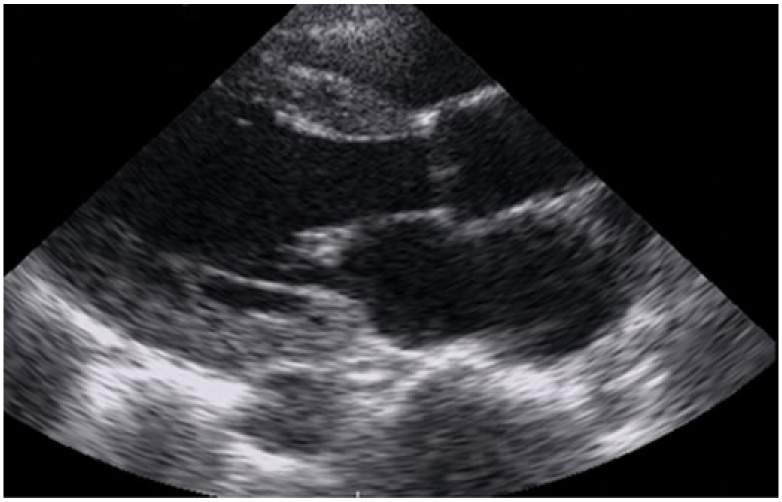
Source: C. M. Baston, C. Moore, E. A. Krebs, A. J. Dean, N. Panebianco:
Pocket Guide to POCUS: Point-of-Care Tips for Point-of-Care Ultrasound, 1st edition.

Q17 Answer: The depth of the soft tissue and the distance from the parietal pleura to the closest underlying structure should always be measured prior to a procedure. Care should be taken to identify the closest underlying structure in real time throughout the respiratory cycle. In this image, the distance between the diaphragm and the lung can be measured at end expiration as an indicator of the volume of fluid in the pleural space.

VIII. CARDIAC ULTRASOUND

Q18: Identify all of the anatomy visible in this ultrasound clip.

FIGURE 15-14

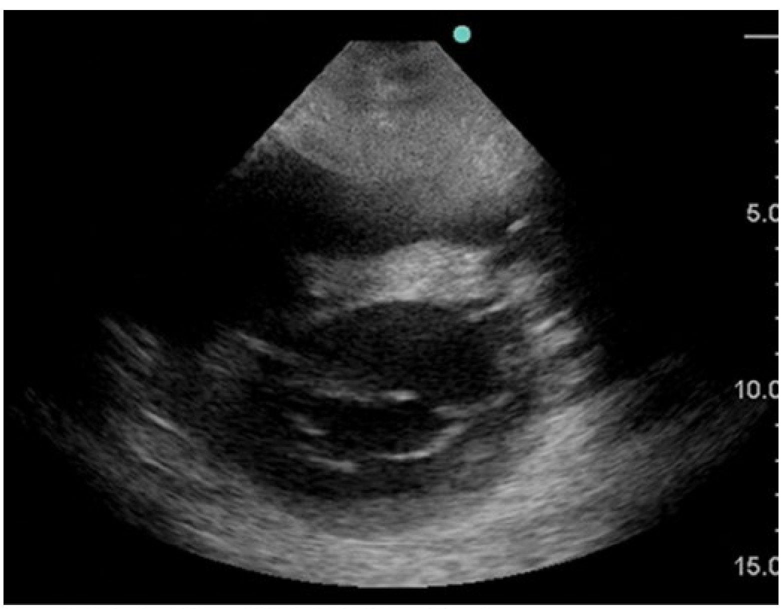


Source: C. M. Baston, C. Moore, E. A. Krebs, A. J. Dean, N. Panebianco: *Pocket Guide to POCUS: Point-of-Care Tips for Point-of-Care Ultrasound,* 1st edition. Copyright © McGraw-Hill Education. All rights reserved.

Q18 Answer: In the parasternal long-axis view, you should be able to identify the left atrium, the mitral valve, the left ventricle, the aortic valve, the aortic outflow track, the descending aorta, the right ventricular outflow tract, the interventricular septum, and in this image, the vertebral body posterior to the left atrium. Remember that in pleural effusions, the fluid goes behind the descending aorta, while pericardial effusions will appear between the descending aorta and the heart in this view.

Q19: Identify all of the anatomy visible in this ultrasound clip.

FIGURE 15-15

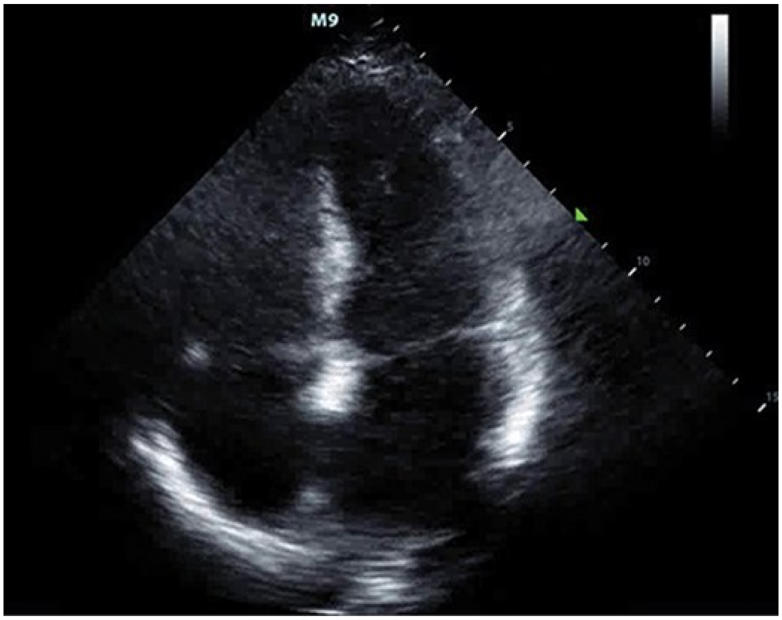


Source: C. M. Baston, C. Moore, E. A. Krebs, A. J. Dean, N. Panebianco: *Pocket Guide to POCUS: Point-of-Care Tips for Point-of-Care Ultrasound,* 1st edition. Copyright © McGraw-Hill Education. All rights reserved.

Q19 Answer: In the parasternal short axis view, you should be able to identify every structure from the apex to the base of the heart by fanning the transducer. In this view the left ventricle, right ventricle, and mitral valve are seen. The leaflets of the valve opening and closing have been described as having a fish-mouth appearance in this plane.

Q20: Identify all of the anatomy visible in this ultrasound clip.

FIGURE 15-16



Source: C. M. Baston, C. Moore, E. A. Krebs, A. J. Dean, N. Panebianco: *Pocket Guide to POCUS: Point-of-Care Tips for Point-of-Care Ultrasound,* 1st edition.

Q20 Answer: In the apical four-chamber view, you should be able to identify the left atrium, mitral valve, left ventricle, right atrium, tricuspid valve, and right ventricle. The aortic valve is occasionally visible if the probe is fanned anteriorly, giving an apical five-chamber view. This view is particularly susceptible to "flipping," so make sure that the indicator is facing the patient's left axilla when the dot is on the right side of the screen per the cardiologist convention.

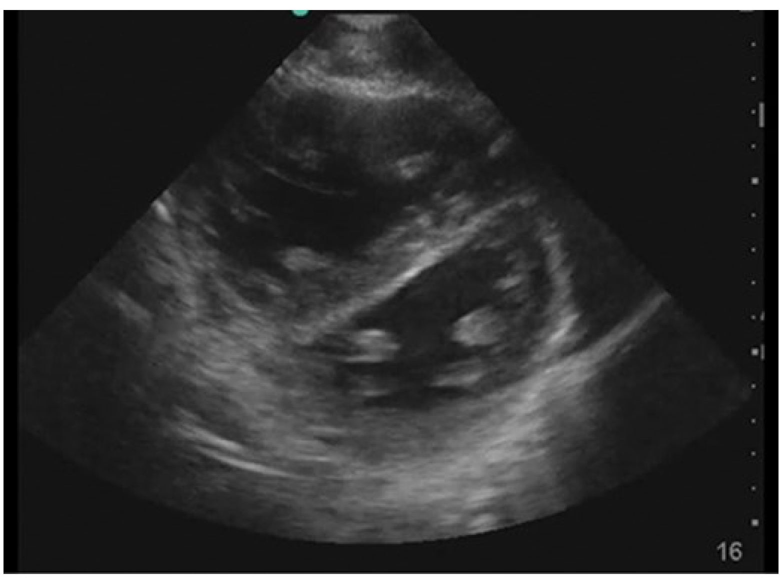
Q21: Identify all of the anatomy visible in this ultrasound clip.

FIGURE 15-17

Q21 Answer: In the subxiphoid four-chamber view, the first structure visible at the top of the screen is the gray heterogeneous liver followed by the bright white line of the pericardium. Then the right ventricle, left ventricle, left atrium, right atrium, tricuspid valve, and mitral valve can all be seen. This image also has a pacemaker wire visible inside the right atrium and right ventricle.

Q22: What pathological states are consistent with this cardiac ultrasound?

FIGURE 15-18



Q22 Answer: This parasternal short axis image shows an enlarged right ventricle pushing the intraventricular septum into the left ventricle, creating a "D" shape. This is a sign of elevated right-sided pressures, seen in chronic pulmonary hypertensive states as well as acute pathology such as massive pulmonary embolus. Pulmonary hypertension is often associated with paradoxical motion of the septum toward the center of the left ventricle during diastole.

Q23: What are three ways to assess the left ventricular ejection fraction?

Q23 Answer:

1. **Fractional shortening**—Measure the change in diameter of the left ventricular (LV) cavity in the parasternal short or long views. A decrease of greater than a third suggests a normal ejection fraction.

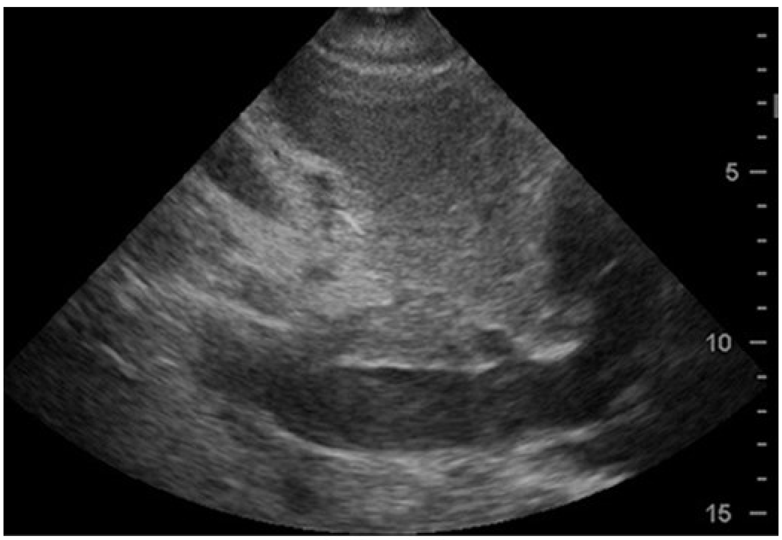
2. **E-point septal separation (EPSS)**—Measure the distance between the anterior leaflet of the mitral valve and the intraventricular septum during the E-wave of diastole. A distance of less than 0.8 cm suggests a normal ejection fraction.

3. **Visual estimation**—The "Gestalt" method has been studied. After seeing a sufficient number of cardiac ultrasounds, the eye can be trained to recognize the appearance of "normal" versus "abnormal" with a high level of reliability.

IX. ULTRASOUND-GUIDED VOLUME ASSESSMENT

Q24: What clinical states are consistent with this ultrasound video of the IVC?

FIGURE 15-19



Source: C. M. Baston, C. Moore, E. A. Krebs, A. J. Dean, N. Panebianco: *Pocket Guide to POCUS: Point-of-Care Tips for Point-of-Care Ultrasound*, 1st edition.

Q24 Answer: This is a large (>3 cm) and unchanging inferior vena cava (IVC). This is seen in volume-overloaded states such as congestive heart failure, but is also seen in elevated right heart pressure states (PE, chronic pulmonary hypertension [pHTN]), cardiac tamponade (where IVC plethora is the most sensitive indicator), restrictive cardiomyopathy, low-volume respiration, and tricuspid valvular pathology.

Q25: What two errors can falsely make an IVC appear to be collapsing? What two errors can falsely make a novice sonographer think the IVC is plump when it is completely flat?

Q25 Answer:

False Collapse

1. Falling off the axis of the IVC in the long axis (see the text for details) makes the IVC appear to collapse.

2. A focal compression, from a hepatic mass or other finding, can make the IVC appear to collapse, especially in the transverse view.

False Plethora

1. Where the IVC meets the right atrium, there is no collapse, which can be misleading in the transverse view. This is why the hepatic veins are such an

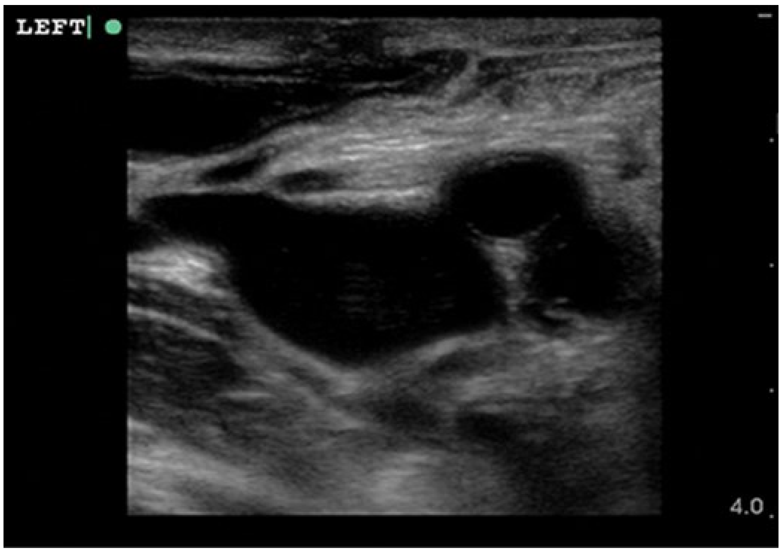
important landmark.

2. With a completely flat IVC, the aorta may be mistaken for the IVC. Remember that if only one vascular structure is seen, it is probably the aorta and the IVC is completely collapsed.

X. LIMITED VASCULAR COMPRESSION ULTRASOUND FOR DEEP VENOUS THROMBOSIS (DVT)

Q26: Identify all of the vascular anatomy in this ultrasound image of the femoral area.

FIGURE 15-20



Source: C. M. Baston, C. Moore, E. A. Krebs, A. J. Dean, N. Panebianco: *Pocket Guide to POCUS: Point-of-Care Tips for Point-of-Care Ultrasound*, 1st edition.

Q26 Answer: The common femoral vein is the largest vascular structure in the center of the screen. The great saphenous vein can be seen entering the common femoral vein at about 2 o'clock. At 11 and 7 o'clock the superficial and deep femoral arteries, respectively, can be seen accompanying the common femoral vein.

Q27: How can a lymph node be distinguished from a thrombosed vein using ultrasound?

Q27 Answer: Lymph nodes are incompressible structures that often are mistaken for thrombi by novice sonographers. A single lymph node has a clear beginning and end, while venous structures are tubes that can be followed. Slide the probe to distinguish the two in the transverse plane. A lymph node will disappear, while a vein will not. Sometimes there are chains of closely contiguous nodes. These can be more difficult to distinguish from a non-compressible vein containing chronic echogenic clot. Usually such nodes are suggested by a more lumpy irregular appearance. If in doubt, obtain a full duplex scan.

XI. ULTRASOUND-GUIDED CENTRAL VENOUS CATHETER PLACEMENT

Q28: Is this an ideal location to attempt internal jugular vein cannulation? If not, how could it be improved?

FIGURE 15-21

Source: C. M. Baston, C. Moore, E. A. Krebs, A. J. Dean, N. Panebianco: *Pocket Guide to POCUS: Point-of-Care Tips for Point-of-Care Ultrasound,* 1st edition.

Q28 Answer: This image shows the internal jugular vein directly overlying the carotid artery and underlying the sternocleidomastoid. While it is possible to cannulate at this site, a posterior puncture of the jugular at this angle will cause a much more serious complication. To find a site where the jugular lies beside instead of over the artery, slide the probe more anteriorly on the neck, try rotating the head, and check more cephalad or caudad locations. For femoral access, it is usually necessary to move more medial and superior if the vein is over the artery.

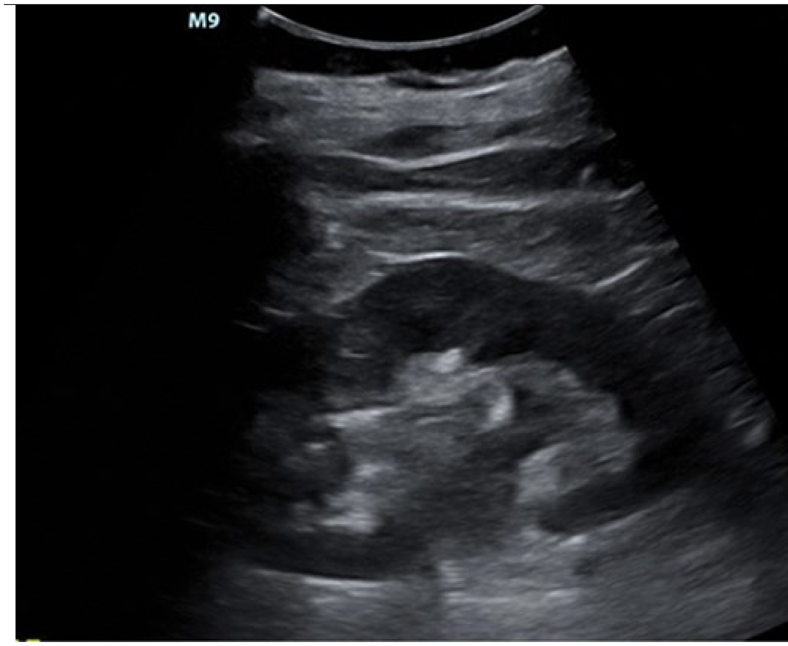
Q29: How can the carotid be distinguished from the jugular using ultrasound?

Q29 Answer: Similar to peripheral veins, central veins can be distinguished from arteries as they are easily compressible, have thinner walls, and are less pulsatile and on the basis of anatomic knowledge of the expected lo-cation. The carotid should be medial to the jugular vein. Color and spectral Doppler can also distinguish veins from arteries, but these require advanced training. Remember that red means blood flow is toward the probe, not that the blood is oxygenated.

XII. RENAL AND BLADDER ULTRASOUND

Q30: What degree of hydronephrosis is present in this ultrasound image?

FIGURE 15-22



Source: C. M. Baston, C. Moore, E. A. Krebs, A. J. Dean, N. Panebianco: *Pocket Guide to POCUS: Point-of-Care Tips for Point-of-Care Ultrasound,* 1st edition.

Q30 Answer: Mild hydronephrosis is seen in this image, as the anechoic space inside the renal pelvis does not separate out the separate calyces (no bear paw) and does not extend into the renal cortex.

Q31: What degree of hydronephrosis is present in this ultrasound image?

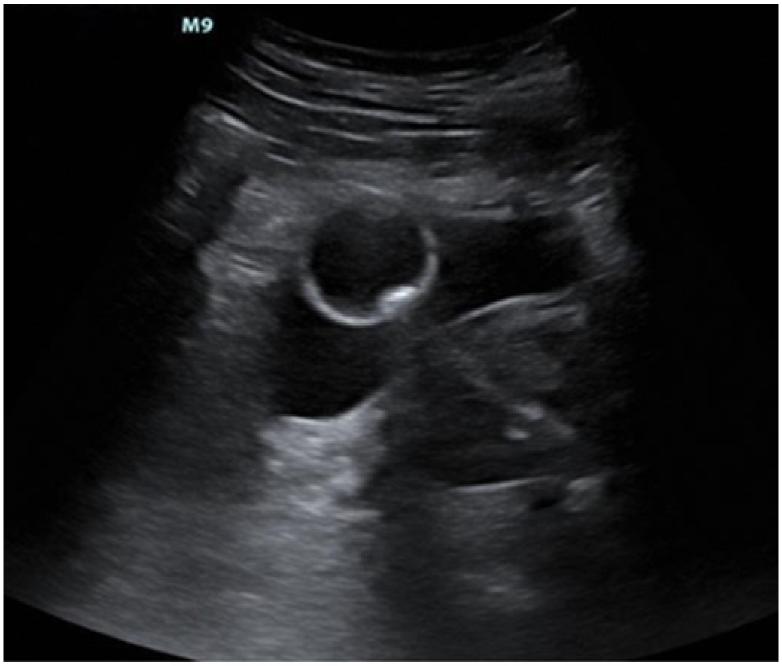
FIGURE 15-23

Source: C. M. Baston, C. Moore, E. A. Krebs, A. J. Dean, N. Panebianco: *Pocket Guide to POCUS: Point-of-Care Tips for Point-of-Care Ultrasound,* 1st edition.

Q31 Answer: This clip shows moderate hydronephrosis. There is blunting of the calices but no effacement of the renal cortex.

Q32: What clinical scenario is consistent with this ultrasound image of the bladder?

FIGURE 15-24



Source: C. M. Baston, C. Moore, E. A. Krebs, A. J. Dean, N. Panebianco: *Pocket Guide to POCUS: Point-of-Care Tips for Point-of-Care Ultrasound*, 1st edition.

Q32 Answer: This image shows a Foley balloon inside an incompletely drained bladder. This could be from a clogged or clamped Foley catheter.

XIII. ULTRASOUND ASSESSMENT OF ABSCESS AND CELLULITIS

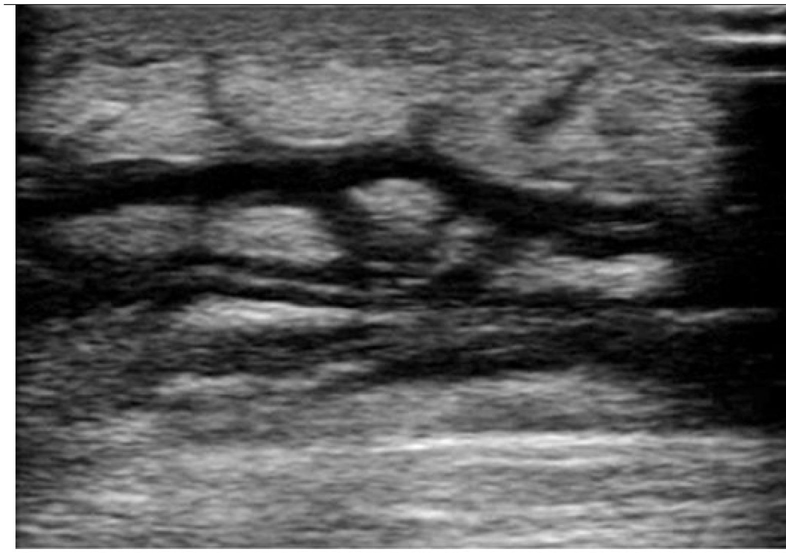
Q33: Name the sonographic findings of an abscess.

Q33 Answer:

- Posterior acoustic enhancement due to the fluid within the abscess
- An irregular border
- A lack of blood flow inside when assessed with color Doppler
- Pusistalsis or squish sign: real-time movement of pus and debris with gentle compression

Q34: What clinical states are consistent with this ultrasound image of soft tissue?

FIGURE 15-25



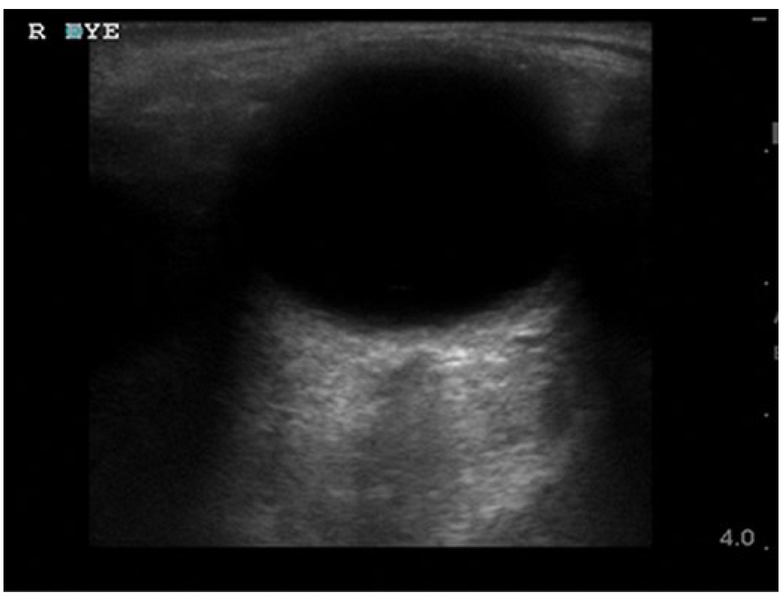
Source: C. M. Baston, C. Moore, E. A. Krebs, A. J. Dean, N. Panebianco: *Pocket Guide to POCUS: Point-of-Care Tips for Point-of-Care Ultrasound,* 1st edition. Copyright © McGraw-Hill Education. All rights reserved.

Q34 Answer: The "cobblestoning" visible in this image is seen in cellulitis and with chronic edema.

XIV. OCULAR ULTRASOUND

Q35: Where should a measurement be taken to look for a sign of increased intracerebral pressure on this ocular ultrasound?

FIGURE 15-26



Source: C. M. Baston, C. Moore, E. A. Krebs, A. J. Dean, N. Panebianco: *Pocket Guide to POCUS: Point-of-Care Tips for Point-of-Care Ultrasound,* 1st edition. Copyright © McGraw-Hill Education. All rights reserved.

Q35 Answer: Measurements of the acoustic nerve should be taken 3 mm deep to the posterior wall of the eye. A 5-mm diameter is normal, while >5 mm is cause for concern (remember a 3-by-5 index card). The data on the performance of this measurement between 5 and 7 mm is still being determined.

Q36: What does papilledema look like on ocular ultrasonography?

Q36 Answer: Papilledema is a tenting of the surface above the optic nerve.