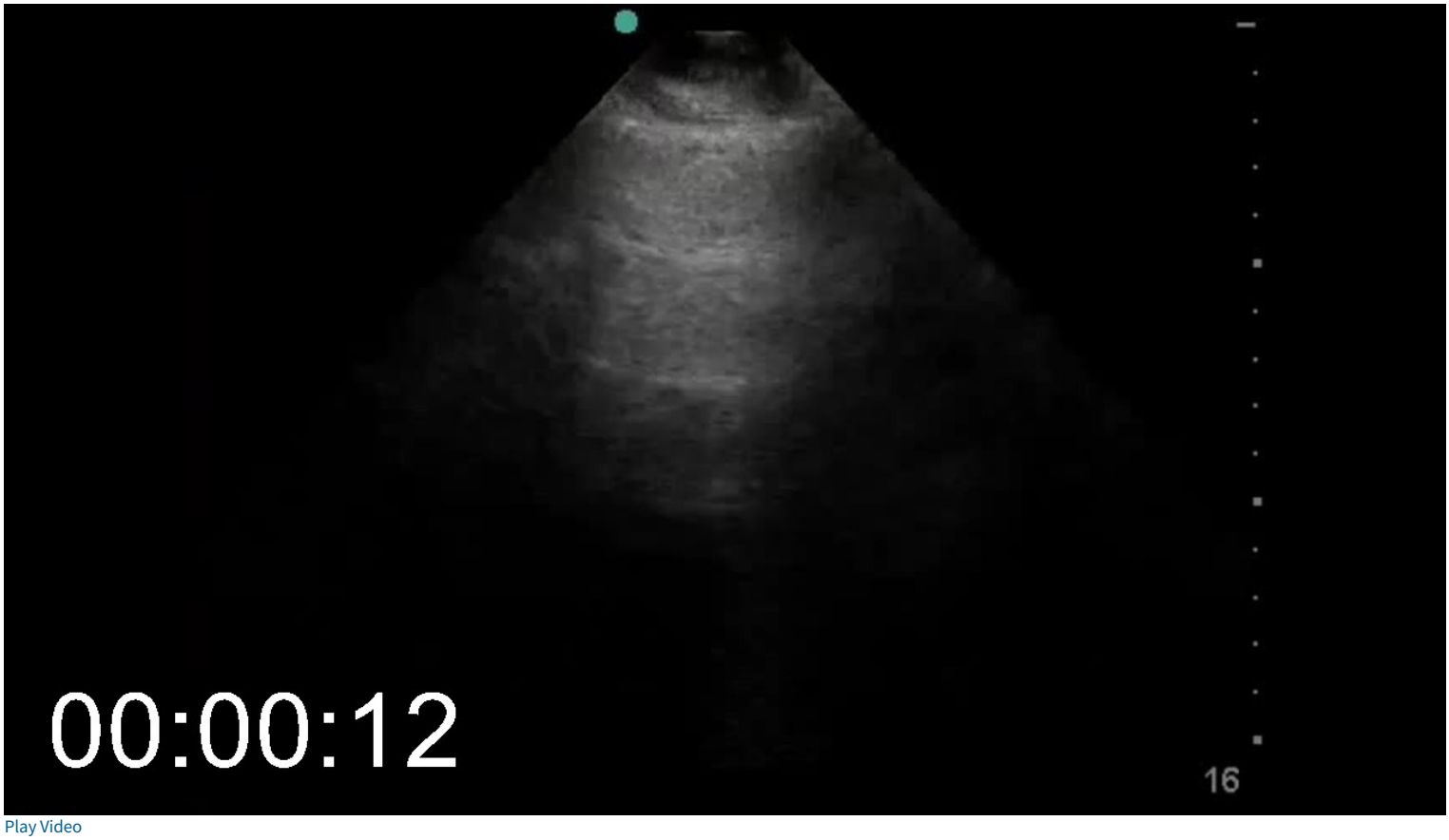
Chapter 6: Lung Ultrasound: Parenchyma and Lung Sliding

KEY IMAGES

Bilateral lung apices/anterior/midlung

Video 06-01: A lines

Lung ultrasound requires identification of the relevant anatomy. With the transducer held longitudinally, with the indicator cephalad, that includes the superior and inferior rib (seen as hyperechoic lines with dense shadows) and the pleura (a bright hyperechoic line just deep to the ribs). The pleura can be seen shimmering or glistening when normal pleural dynamics are observed. This video also demonstrates A-lines, arising as a result of the reverberation artifact between the pleura and the transducer. This is consistent with normal lung parenchyma in this video.



Play Video

Hand position for all views, anchor hand on skin

Figure 6-1

Bilateral lung bases

Anterior and posterior axillary lines starting at level of diaphragm and sliding up until lung curtain

Video 06-02: Lung curtain

At the base of the lung it is important to identify the diaphragm and the underlying viscera. In this case, the video was taken on the patient's right side, so the liver and diaphragm can be seen on the right side of the screen. The left side of the screen is lung parenchyma (remember that left is cephalad and right is caudad). As the patient inspires, a curtain of grey air artifact sweeps from left (superior) to right (inferior) obliterating the view of the diaphragm and liver. This effectively rules out pleural effusion at this location.

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Hand position for lung base, anchor hand on skin

Figure 6-2

B-mode lung sliding

Video 06-03: Lung sliding

Using the linear transducer allows a much higher resolution evaluation of the pleura. The glistening and shimmering is much more apparent, especially in comparison to the fascial planes and muscle fibers more superior to the pleura. Small vertical artifacts are also visible at several places during the respiratory cycle. These have no pathological significance, but also rule out pneumothorax at that location.

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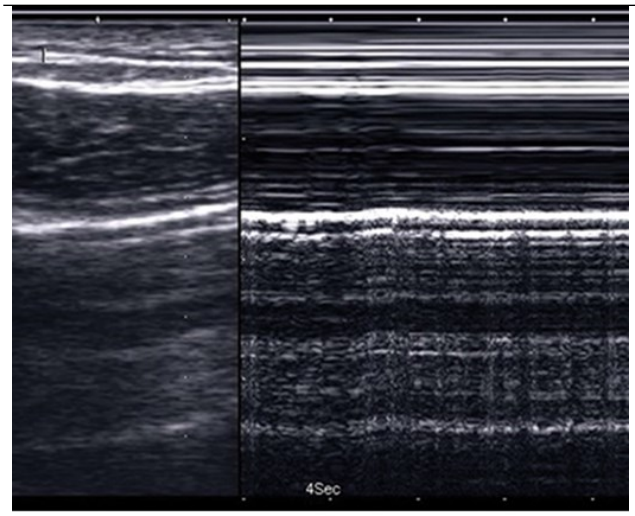
M-mode lung sliding

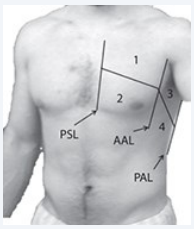
Figure 6-3



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.

ACQUISITION TIPS

- Most lung ultrasound findings are actually ultrasound artifacts. Use the Lung Exam preset to avoid the suppression of artifacts. If you do not have this preset, turn off multibeam imaging and set “persist” to 0 (which turns off frame averaging).
- Video clips are preferred to stills because of the dynamic nature of lung ultrasound findings.
- The curvilinear and phased-array probes are preferable for viewing structures deep to the pleura such as B-lines, consolidations, and large effusions.
- The linear and curvilinear probes are better for seeing lung sliding and other pleural findings.
- For evaluation of B-lines and parenchyma, start at a depth of 10 to 15 cm.
- The probe should be perpendicular to the pleura for optimal visualization of A-lines, B-lines, and the pleura.
- Hold the transducer longitudinally (with the indicator toward the patient's head), bridging two ribs.
- Hold your hand perfectly still and anchored via fingers against the wall to avoid movement.
- Observe the cyclic movement of the lung and pleura through the respiratory cycle.
- If lung sliding is not clear, try decreasing the depth (so the pleura is in the center of the screen), decreasing the gain (the pleura will be the brightest thing on the screen), selecting M-mode imaging, and changing to a high-frequency transducer (linear or curvilinear).

For the anterior and lateral chest examination, place the transducer in each of the four lung zones shown for each side of the thorax. AAL = anterior axilary line; PAL = posterior axilary line; and PSL = parasternal line.	
The bilateral posterior lung fields are primarily divided into upper and lower.	

- There are other proposals for zones, ranging from 3 zones on each side up to 14. We believe this distribution (supported by the International Consensus on Lung Ultrasound) balances accuracy and the time to perform an examination.

- Identify the relevant anatomy: Two ribs and the pleural line beneath them.
- To obtain an M-mode recording of lung sliding, press the M-mode button and align the sensing line through the middle of the pleural line. Then engage M-mode and freeze it after at least one full respiratory cycle to demonstrate either the “seashore” (normal expanded lung) or the “barcode” (also known as “stratosphere”) sign.

INTERPRETATION

- **Lung sliding:** Artifact of visceral pleura moving against parietal with respiration.
  - **Present:** No pneumothorax (PTX).
  - **Absent or Nonspecific:** In the absence of any lung disease, indicates PTX. Found with blebs, inflammation, scarring, adhesions, and apnea.
  - **Lung point:** A dynamic alternation between sliding and absent lung sliding within a single rib space. Very strongly associated with pneumothorax.
  - **Lung pulse:** Brief lung sliding in time with cardiac pulsations. Useful to rule out pneumothorax in patients with stiff lungs, pulmonary contusions, parenchymal consolidations, apnea or right mainstem intubation.
  - **M-mode**: PTX appears as “bar-code” (also known as “stratosphere”) sign, while normal lung reveals the “seashore” sign.
- **A-lines:** Caused by reverberation between the transducer surface and parietal pleura. It does not discriminate between PTX, normal lung, COPD, or asthma. A-lines will not appear if probe is not perpendicular to pleura, and are obliterated by B-lines.
- **B-lines:** Caused by reverberation in the alveoli or interstitium. They appear as vertical, laser-like artifacts from pleura to bottom of screen, and they move with respiration. Indicate abnormal extravascular lung fluid or interstitial fibrosis. Rule out PTX. Individual B-lines can coalesce into a general white-out of the lung.
- **Consolidation:** Collapsed or “hepatized” lung (looks like liver). Due to pneumonia, atelectasis, contusion, infarct, or tumor.
  - **Dynamic air bronchograms:** Hyperechoic structures that move with respiration in consolidated lung, concerning for pneumonia.
  - **Shred (also known as fractal) sign:** Irregular transition zone between consolidated and aerated lung seen underlying pneumonic consolidations.
- **Subpleural consolidations**: Small hypoechoic areas underneath the pleura, can be seen in pneumonia, pulmonary embolus, and acute respiratory distress syndrome (ARDS).
- **Z-lines**: Faint vertical lines that do not go to the bottom of the screen and do not obliterate A-lines. Their presence rules out PTX. No known pathological significance.
- **Pleural effusions**: Hypoechoic areas, usually in costophrenic sulci, appearing between diaphragm and lung. Loculated effusions can be in other areas.

Key pathological conditions and associated lung ultrasound abnormalities

Pathological State	Lung Ultrasound Findings
Pulmonary edema	Diffuse B-lines with lung sliding.
Acute respiratory distress syndrome	Heterogeneously diffuse B-lines with or without subpleural consolidations. Lung sliding may be absent in severe cases.
Pneumothorax	A-lines with absent lung sliding with or without lung point.
Pulmonary embolus (less reliable)	A-lines early, B-lines later, with subpleural consolidations.
Pneumonia	Focal B-lines, sometimes with subpleural consolidations, or consolidated lung, with or without shred sign, dynamic air bronchograms, or effusion.
Chronic obstructive pulmonary disease (COPD)/asthma	A-lines with lung sliding unless severe blebs are present.
Pleural effusion	Hypoechoic collection in pleural space with or without compression atelectasis of lung.
Pulmonary fibrosis	B-lines.
Right mainstem intubation	Lung sliding on right, but not left. Lung pulse present bilaterally.

EXAMPLES OF PATHOLOGY

Consolidation with dynamic air bronchograms

Video 06-04: B lines

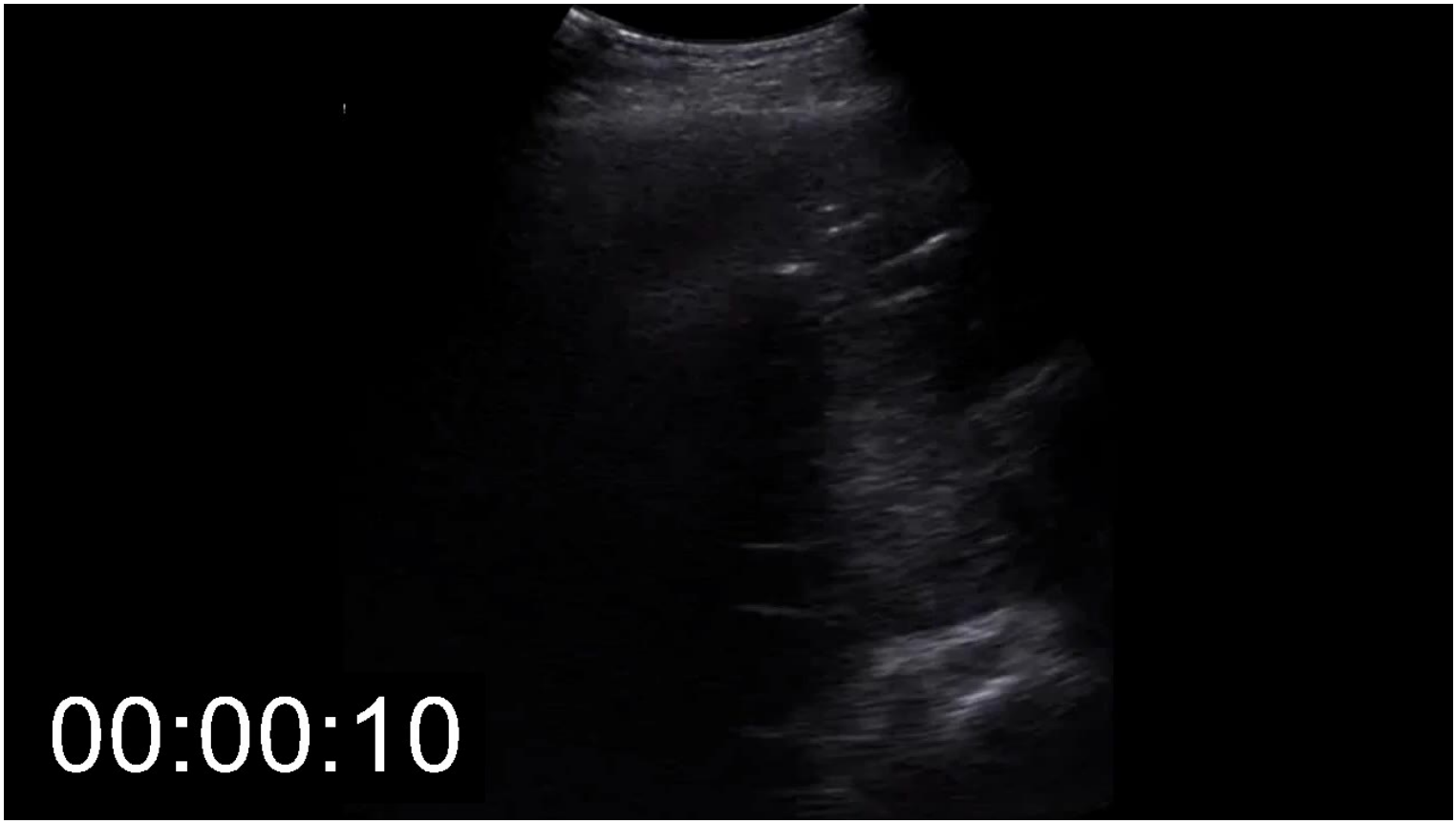
This video was taken on the anterior chest of a patient with known pulmonary edema. Rib shadows can be seen on either side of the screen, with the bright pleural line just deep to the ribs. In addition to the apparent pleural sliding, multiple vertical artifacts can be seen going from the pleura to the bottom of the screen. These B-lines indicate and alveolar or interstitial process. This video shows a rib space with 6 to 7 B-lines, which at one point in the respiratory cycle coalesce into a single hyperechoic haze occupying 60% of the rib space. More than 3 lines (or 30% of the rib space) is consistent with a pathologic state.

Play Video

Figure 6-4

Video 06-05: Consolidation

This video was taken at the left lung base of a patient with pneumonia. The lung is so densely consolidate and filled with purulent material that it appears to be a solid organ on ultrasound. The echodensity is similar to that of the liver, so this is sometimes referred to a hepatization. In this video, bright white lines in the consolidation can be seen moving with the respiratory cycle. These are referred to as dynamic air bronchograms and are thought to be caused by pus moving in airways, suggesting pneumonia as the etiology of the consolidation.



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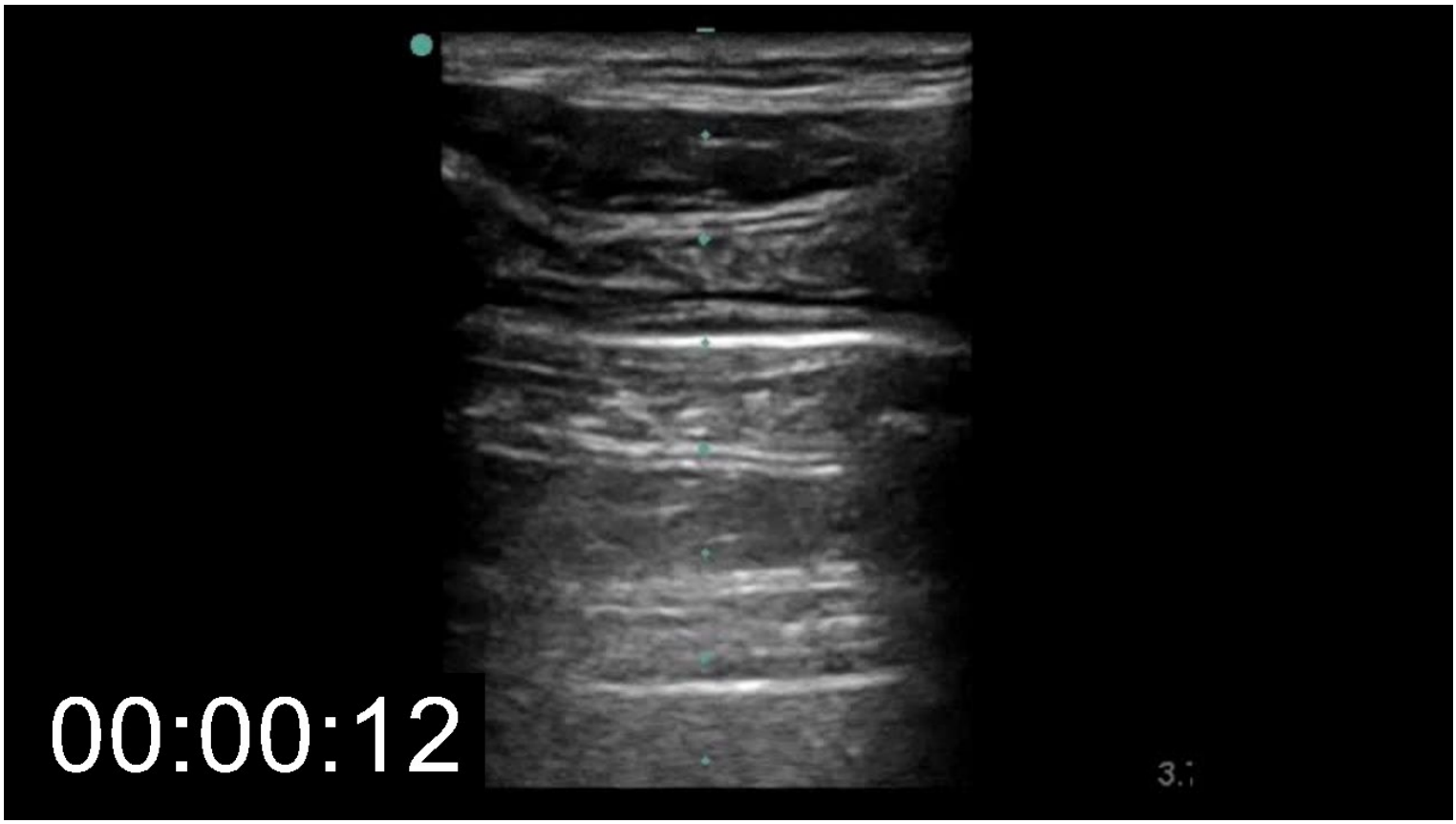
Video 06-06: Stratosphere sign

M mode imaging of this video would show the stratosphere or barcode sign of impaired lung sliding. This patient had a pneumothorax, and so the pleural line does not glisten or shimmer. The rib shadows can be seen on either side of the bright pleural line that moves, but does not change in the way expected in normal lung. It is worthwhile to compare this directly to any of the videos of normal lung in this chapter.



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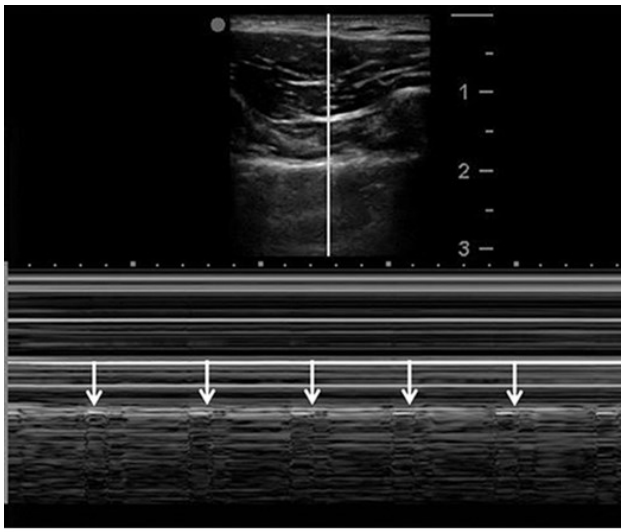
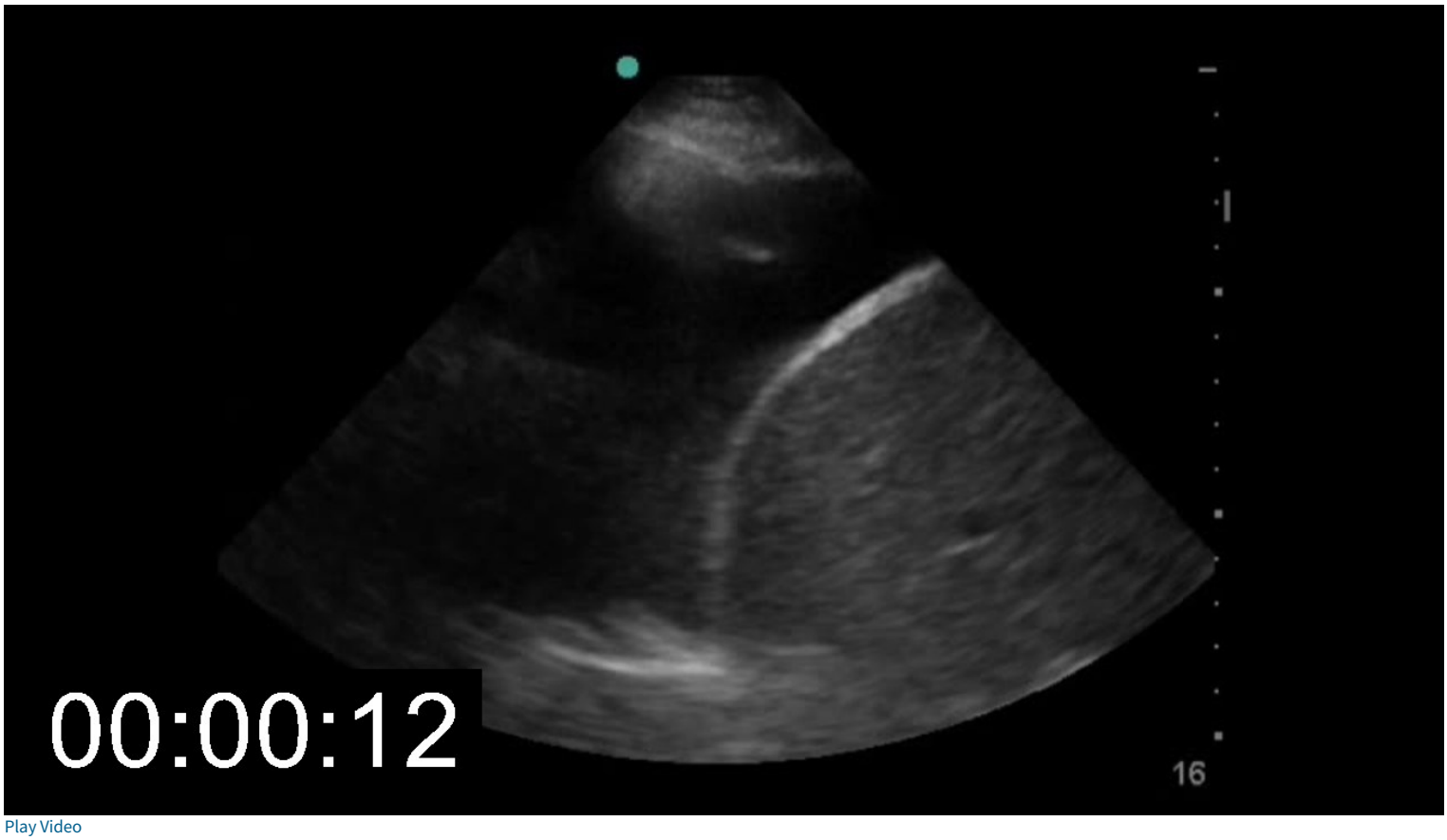
Lung pulse (arrows)

Figure 6-5



Video 06-07: Pleural effusion

In this patient with profound volume overload, the liver can be seen on the right side of the screen with the bright overlying diaphragm. A thin tentacle of atelectatic lung is visible waving in the anechoic effusion. A rib is visible on the left side of the screen casting a dense shadow. This is a good example of the best way to differentiate the dark rib shadow from anechoic fluid. The rib shadow goes all the way to the bottom of the screen, while the fluid causes the structures deep to it to appear brighter, due to posterior acoustic enhancement.



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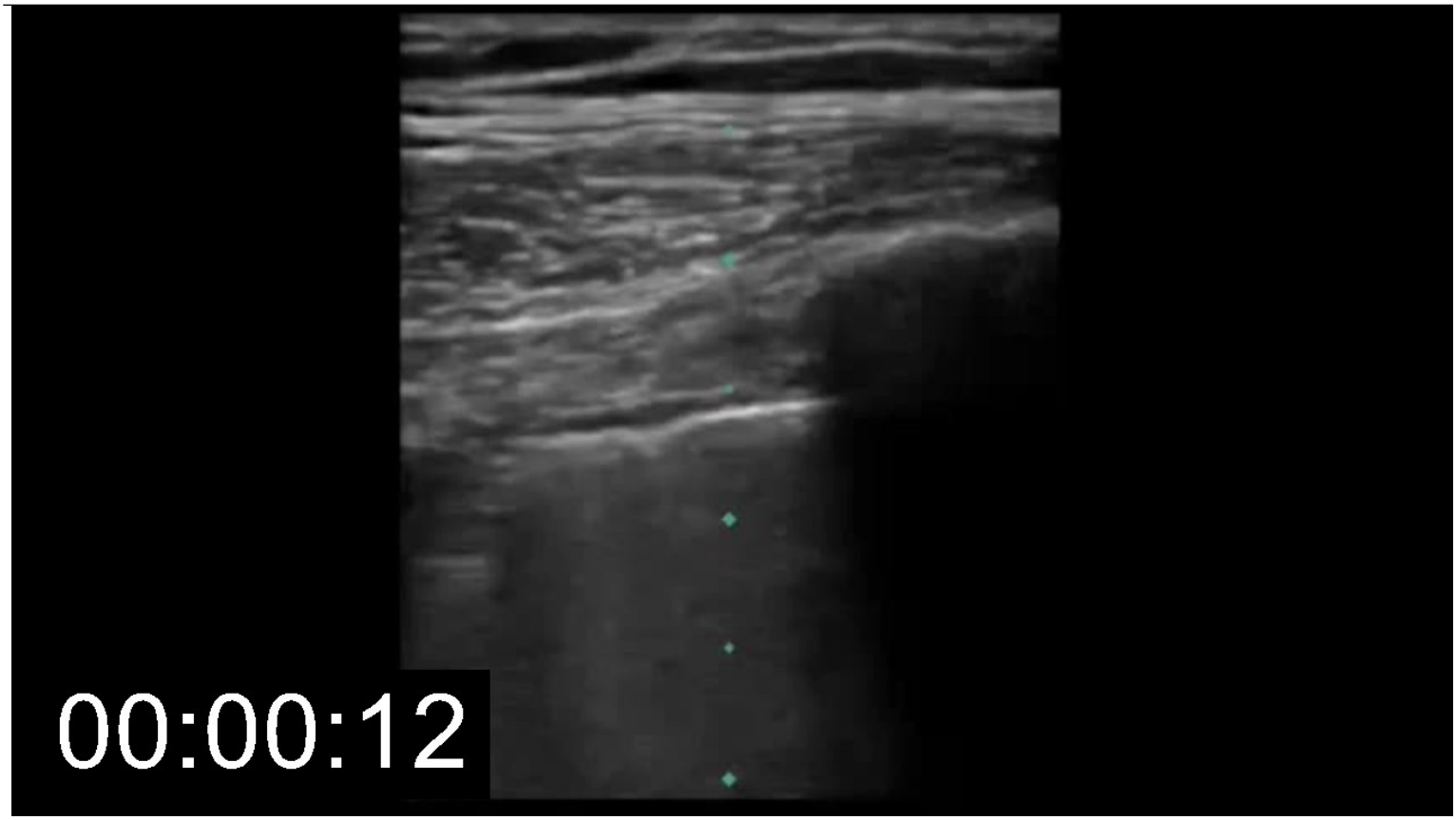
Video 06-08: Subpleural consolidations

The pleural line in this video is notably less smooth than in a healthy lung. In addition, a small hypoechoic space can be seen between the pleural line and the soft tissue on the left side of the screen toward the end of the clip. These subpleural consolidations are associated with pneumonia, pulmonary emboli, and other inflammatory states.



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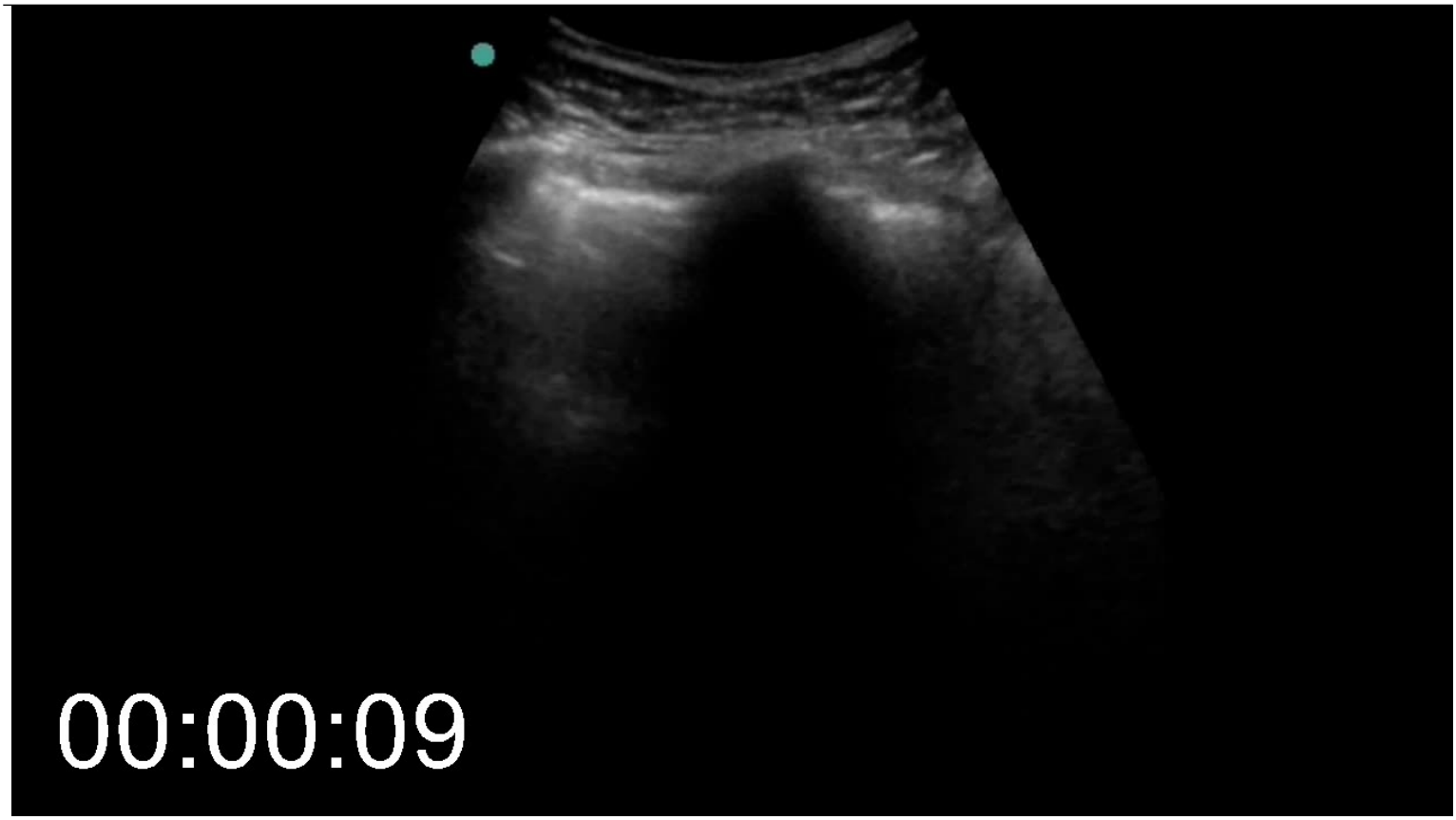
Video 06-09: Z lines

The pleural line of a healthy patient in this video appears to be normally sliding with slow respirations, but about halfway through the respiratory cycle several vertical artifacts can be seen which do not go all the way to the bottom of the screen, but instead merely stand out from the background air artifact. These Z-lines are more commonly seen in the elderly, but have no known pathological significance. They do, however, rule out pneumothorax.



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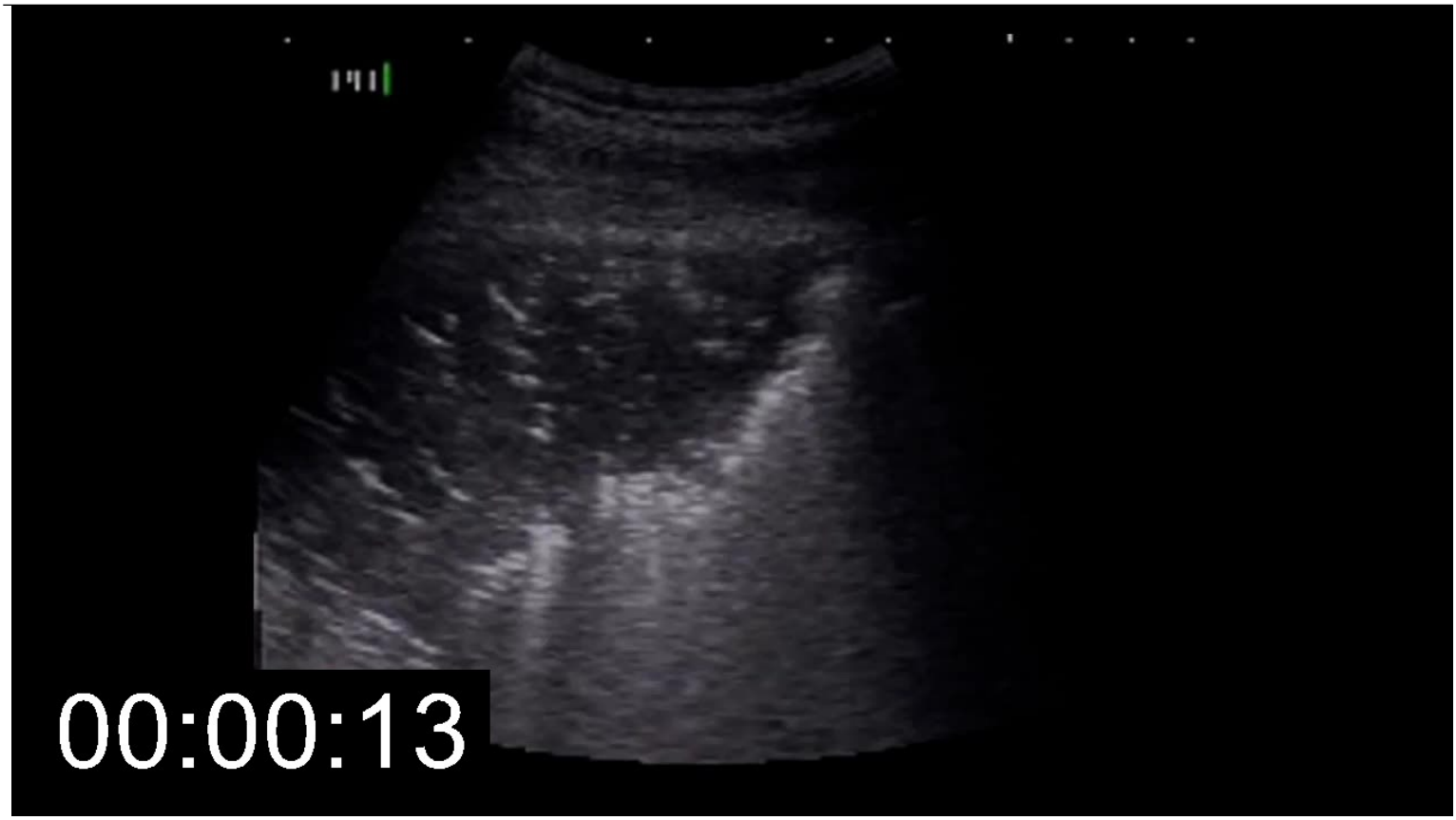
Video 06-10: Shred sign

This video shows a densely consolidated lung overlying aerated lung. The aerated lung has what appears to be a "shredded" pleural line where the air artifact begins. This sort of irregularity to the pleural line is usually seen in states like pneumonia.



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