

Lung sonography in the diagnosis of pneumothorax.

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Learning objectives

1. Present the sonographic signs of the normal pleura.
2. Illustrate the sonographic patterns and artifacts related to pneumothorax.

Background

Pneumothorax is a frequent diagnostic problem in the Intensive Care Unit (ICU). It occurs with an incidence of 3 - 8% in mechanically ventilated patients and it is often a complication of trauma, mechanical ventilation, ARDS and diagnostic and therapeutic procedures that take place in the ICU.

Computed Tomography (CT), which is considered the gold-standard in the diagnosis of pneumothorax, is often not easy to perform and bedside chest X-ray has a low sensitivity.

The lung is considered poorly accessible by sonography. However, lung ultrasonography (US) has been proven to be a useful method for the evaluation of the pleura and especially in the detection of pneumothorax. The technique is particularly suited to bedside use in the intensive care unit, due to low sensitivity of chest X-ray and to the fact that computed tomography (CT) is not easy to perform.

Images for this section:

Lung ultrasonography

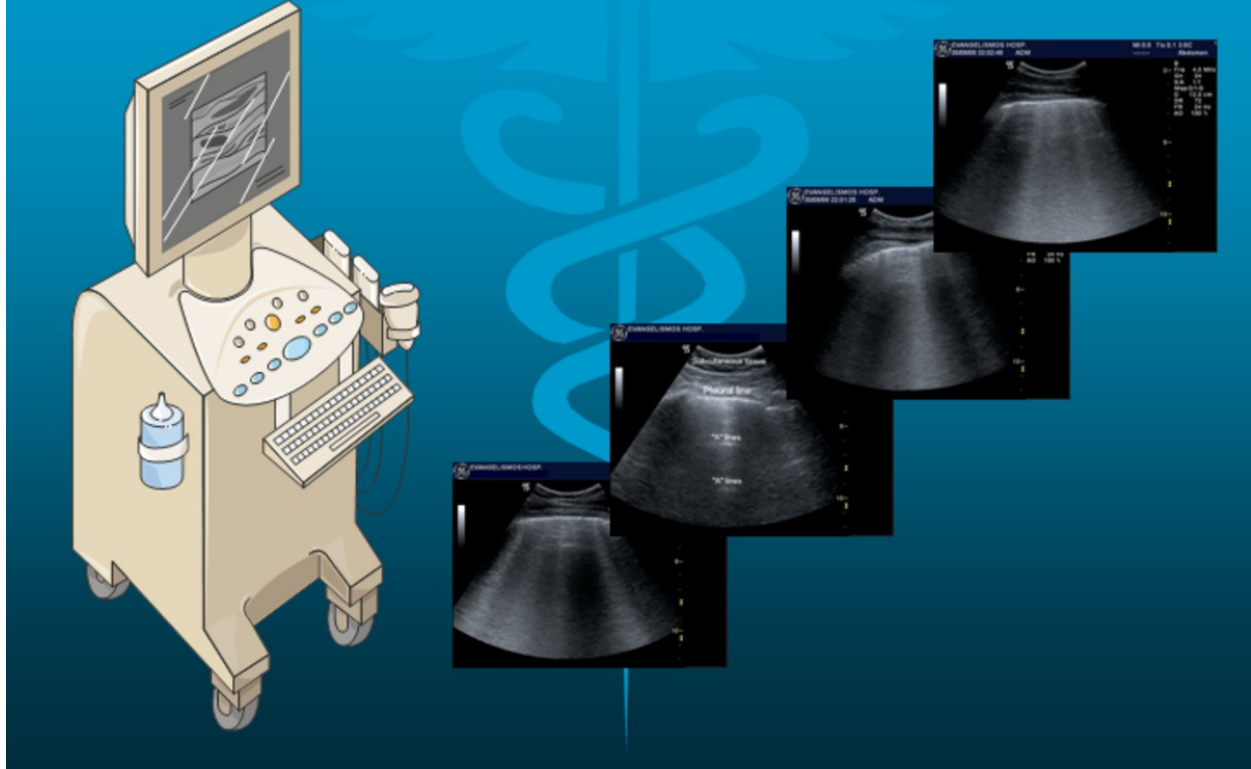


Fig. 1: Lung ultrasonography

Imaging findings OR Procedure details

Basic principles-Technique

Sonographic study of the pleura is performed using linear and convex probes. A high frequency (5-7.5 MHz) linear or convex transducer is appropriate for surface structures such as pleura. Patients are scanned using an intercostal approach from the second down to the fourth or fifth intercostal space of the anterior and the lateral chest using parasternal, midclavicular and midaxillary lines as anatomical landmarks. The transducer is moved longitudinally and transversely to visualize the lung surface through the intercostal spaces avoiding the acoustic restriction of the ribs.

Sonographic lung anatomy

Basic sonographic anatomic landmark for the examination of the lung constitutes the localisation of pleura. Sonographically is described as an intense hyperechoic line that is created by the surface of visceral pleura against the surface of air filled lung and indicates the location of pleura in a normal ultrasound pattern (pleural line) (Fig.1,2). The thoracic wall is recognized by the characteristic posterior shadowing of the ribs. Intercostal muscles are extended between the ribs, creating a useful intercostal sonographic window. Intercostal muscles are extended between the ribs, creating a useful intercostal sonographic window.

Normal lung sonographic signs and points

Lung sliding: It is described as a hyperechoic line moving forward and back during the respiration recognisable in B-mode in real time (Fig.1). Represents the normal sliding of the two layers of the pleura.

Seashore sign: It is a dynamic sonographic sign of the normal lung (M-Mode). It is described as a complex picture of parallel lines that represents the static thoracic wall above the pleural line and granulous, sandy pattern below the pleural line that represents normal pulmonary parenchyma (Fig. 3). It is mainly used in cases in which the lung sliding sign is not diagnostic for the presence of pneumothorax.

"A" Lines: They are horizontal parallel hyperechoic lines, parallel to the pleural line, a basic lung artifact of the normal lung (Fig.1,2). They are produced by the intense reflection in the surface of contact of soft tissue and the surface of air-filled lung.

Pathologic signs, points and patterns

"B" lines or "comet tail artifacts": It is the presence of at least 3 in number hyperechoic lines that are perpendicular to the pleural line. The number of these vertical "B" lines depends on the degree of lung aeration loss and their intensity increases with inspiratory movements. Their presence excludes the existence of pneumothorax. "Comet tail artifacts" can be single or multiple, localized or disseminated to the whole anterior chest wall. They are from each other separated depending on the distance in lines B3 and B7 when the distance is # 3mm and #7 mm respectively. A distance between multiple lines "B" #3 mm (B3 lines) is correlated with ground glass pattern (Fig.4). A separation of artifacts of about 7mm indicates thickening of the interlobular septa (B7 lines) (Fig.5)

Lung point: It is a specific sonographic sign in the diagnosis of pneumothorax. Indicates the point of transition between the pneumothorax pattern (absent lung sliding plus "A" lines) at the expiration phase replaced by a normal lung pattern (lung sliding or pathologic comet-tail artifacts) at the expiration phase. In normal conditions, in M-mode, lower to the pleural line, the movement of the 2 layers of pleura creates a granulous "pattern". On the contrary, in pneumothorax, the absence of motion of the 2 layers because of the presence of air, is characterized in M-mode by a horizontal pattern (Fig.6).

US findings excluding pneumothorax

- Localisation of the pleura was the first step in the US examination of the lung (Fig.1,2)
- In a normal lung, it is important to image the normal sliding of the two layers of the pleura (lung sliding), (Fig.1,2)
- Comet-tail artifacts can arise from pleural line indicating alveolar interstitial lung disease (Fig.4,5). Their presence exclude pneumothorax.

US findings in pneumothorax

- As a consequence of pneumothorax and interposition of gas between visceral and parietal pleural layers, lung sliding is abolished, and only longitudinal reverberations ("A" lines) of the motionless pleural line can be seen (Fig.7)
- Comet-tail artifacts arising from the pleural line cannot longer be visible.
- Lung point (Fig.6)

Limitations of the method

- Subcutaneous emphysema
- Bullous emphysema
- Pleural adhesences
- Chronic obstructive pulmonary diseases
- Obesity
- Long experience

Images for this section:

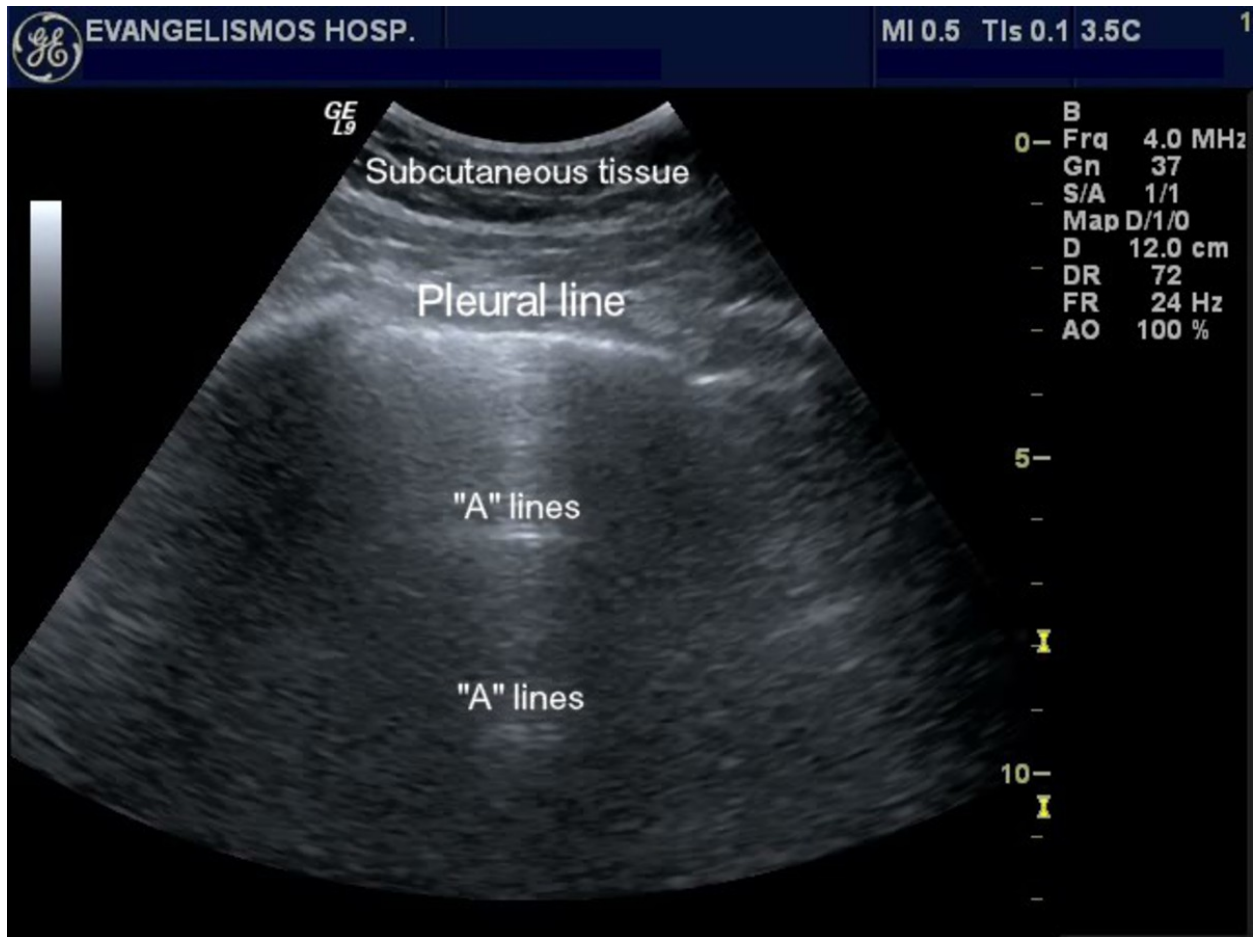


Fig. 1: Sono anatomy of the chest. US appearance of the echogenic subcutaneous tissue and the hypoechoic with multiple echogenic fascia intercostal muscle. Intercostal visualization of pleural line and the horizontal lines parallel to the pleural line, called "A" lines.



Fig. 2: Real-time sonographic view of a normal lung with lung sliding and the presence of "A" lines.

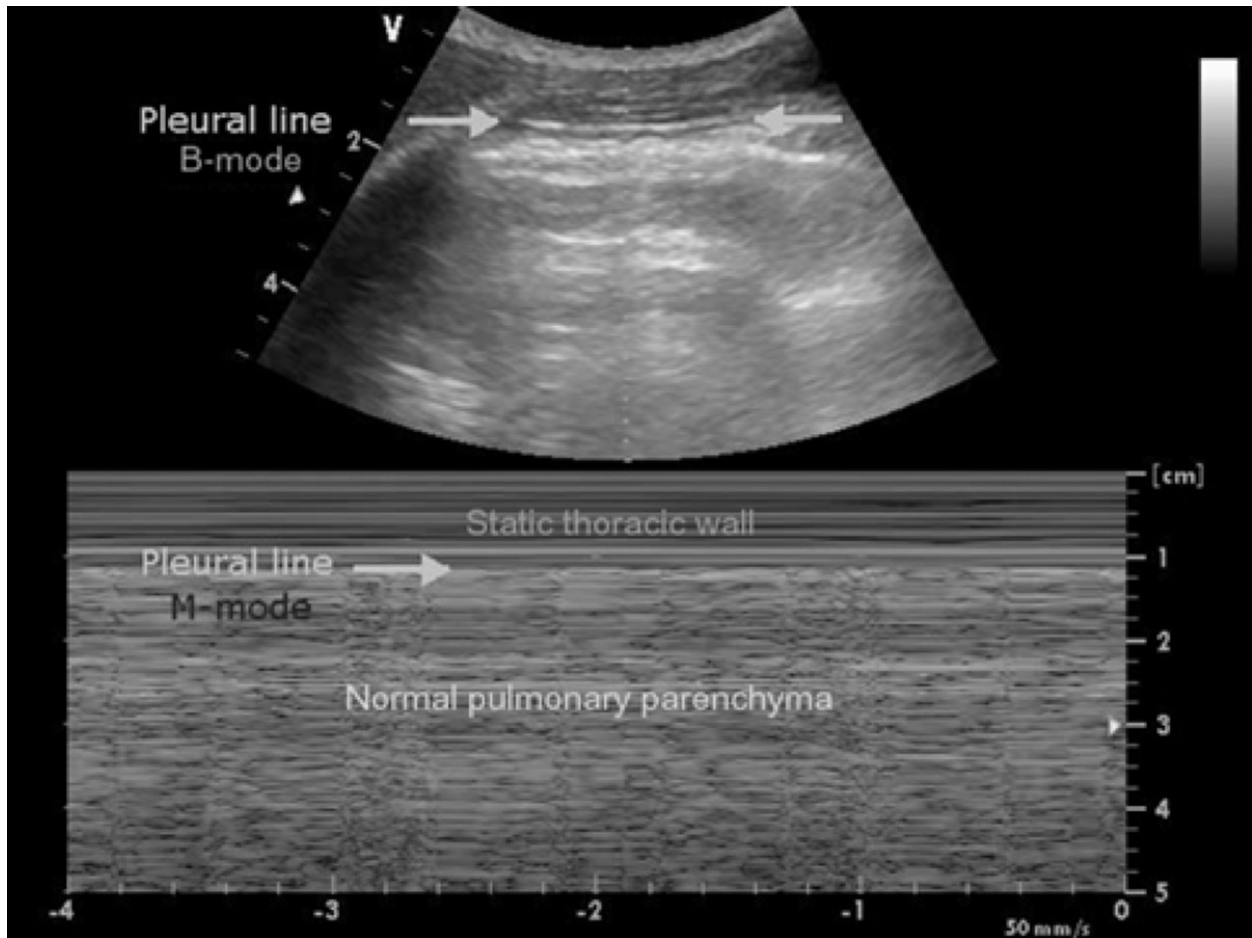


Fig. 3: Seashore sign. Correspondence of pleural line in B-mode and M-mode. In M-mode a complex picture of parallel lines that represents the static thoracic wall above the pleural line and granulous, sandy pattern below the pleural line that represents normal pulmonary parenchyma.

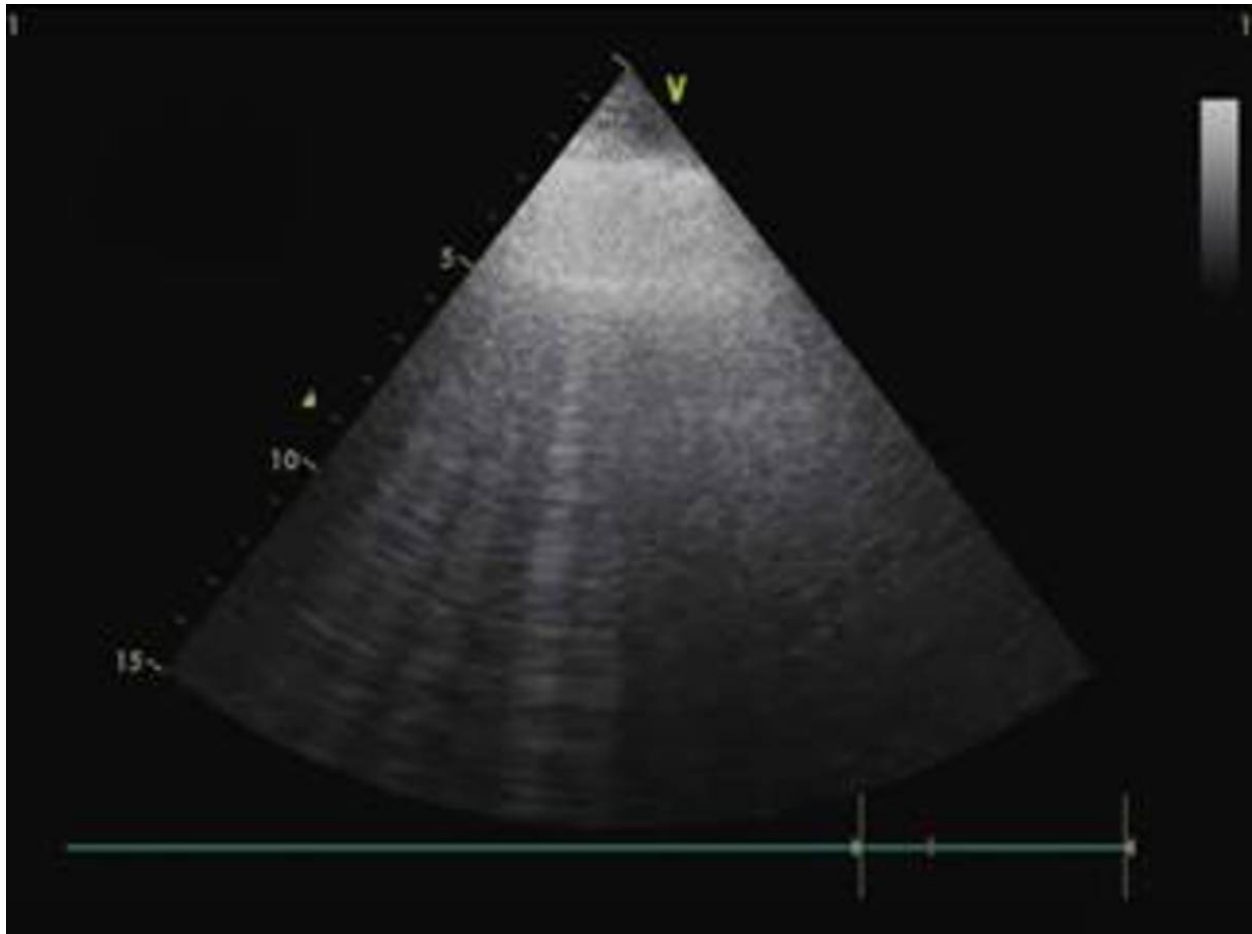


Fig. 4: US shows multiple comet tail artifacts perpendicular to the pleural line. These hyperechogenic artifacts arise from the pleural surface and are separated from each other by 3 mm (B3 lines) and exclude the presence of pneumothorax.

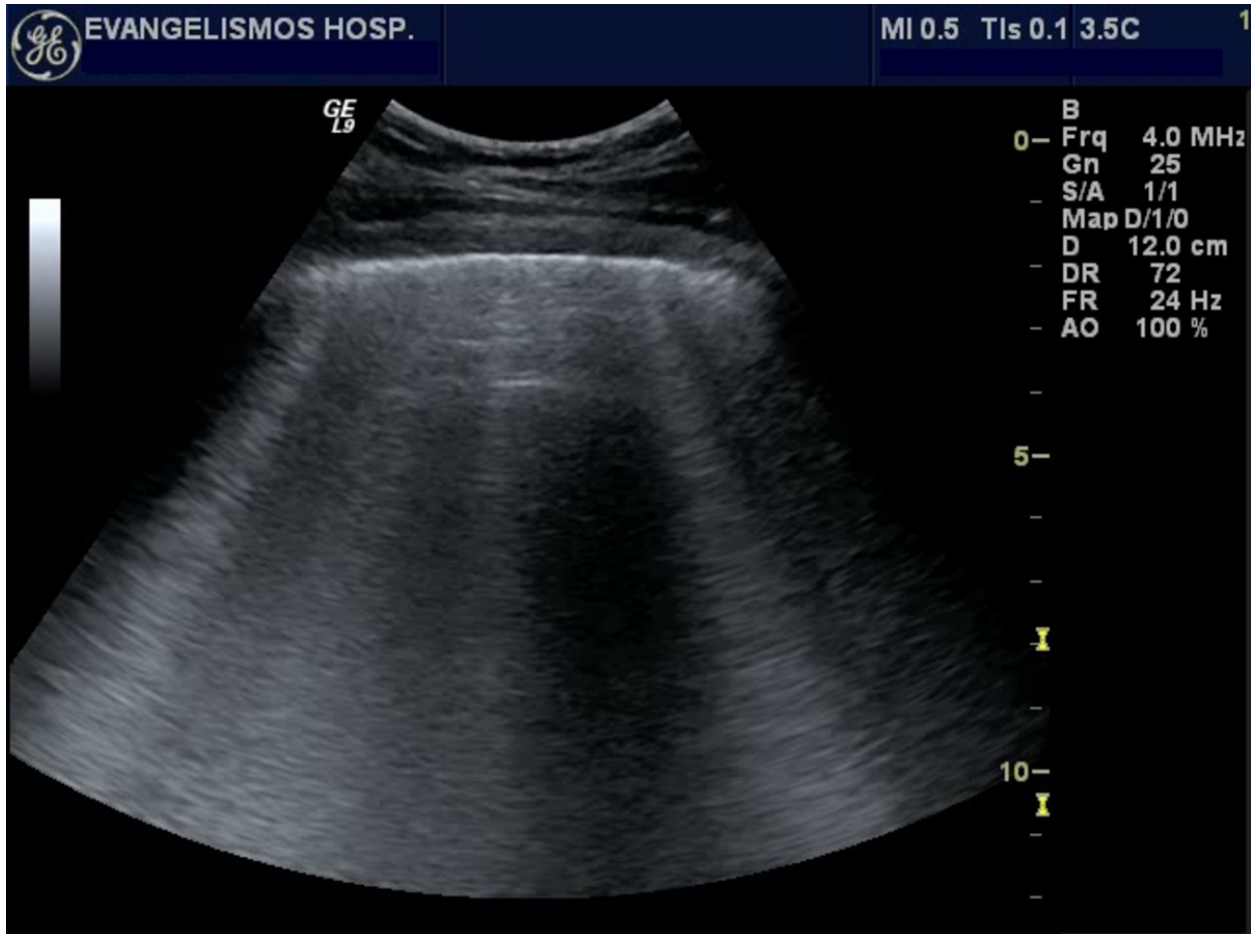


Fig. 5: US image depicts several comet-tail artifacts arising from the pleural lines separated from each other by 7 mm (B7). Their presence exclude pneumothorax.

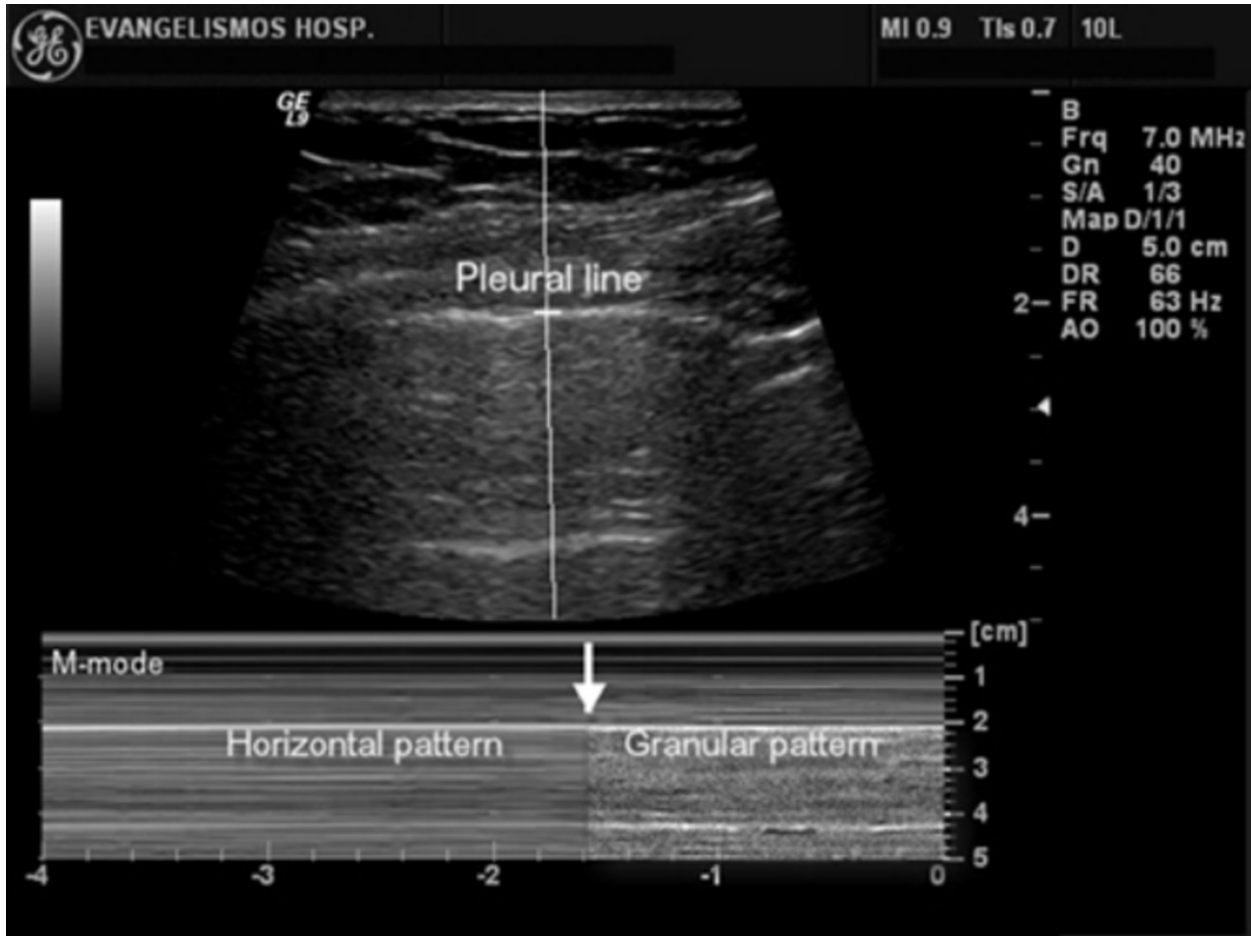


Fig. 6: The lung point. Time motion mode (M-mode) shows the sudden (white arrow) replacement of the pneumothorax pattern (horizontal pattern) into the normal pattern (granular pattern) below the pleural line.

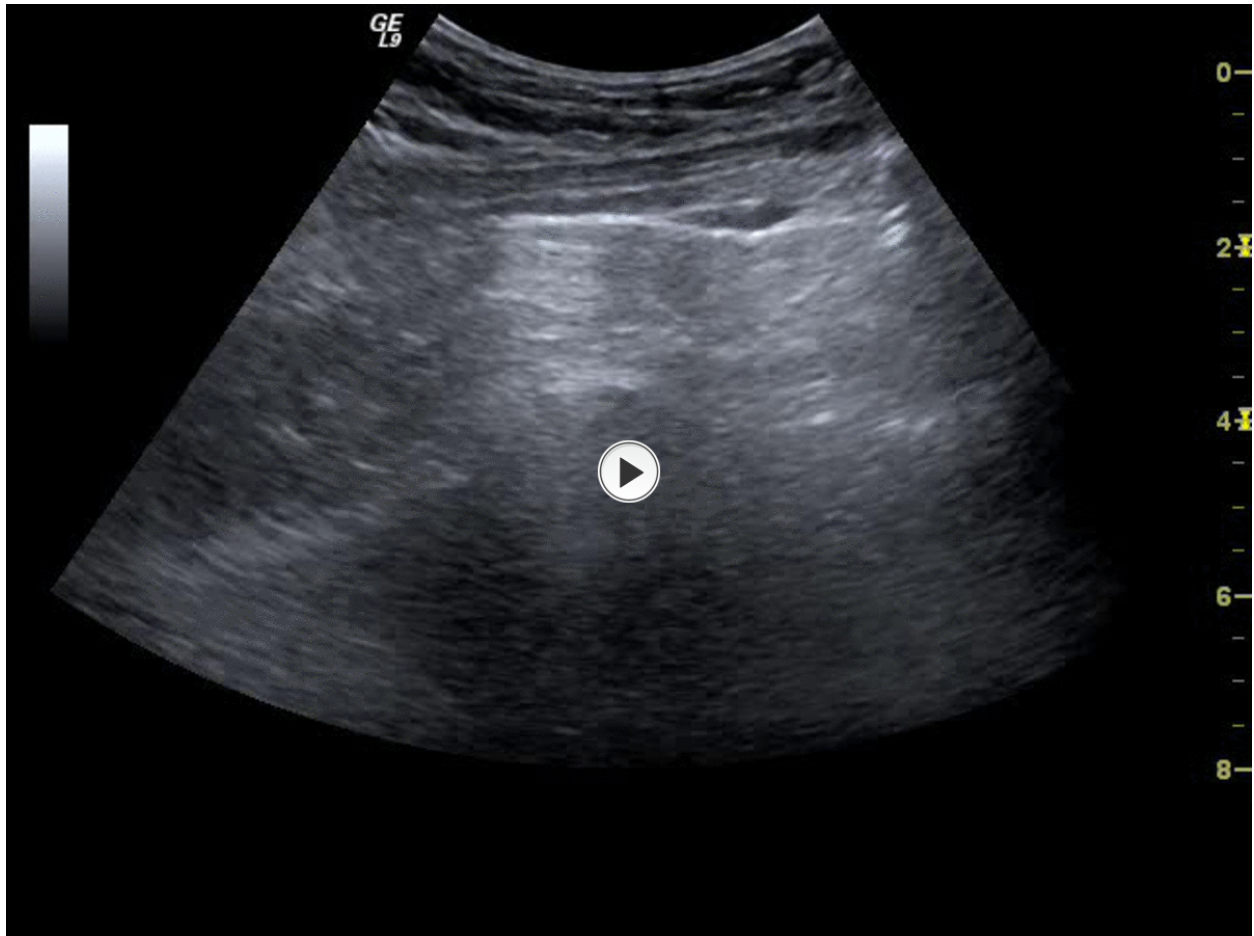


Fig. 7: US video showing pneumothorax with abolition of the lung sliding and coexistence of "A" lines, in a critically ill patient examined in the supine position.

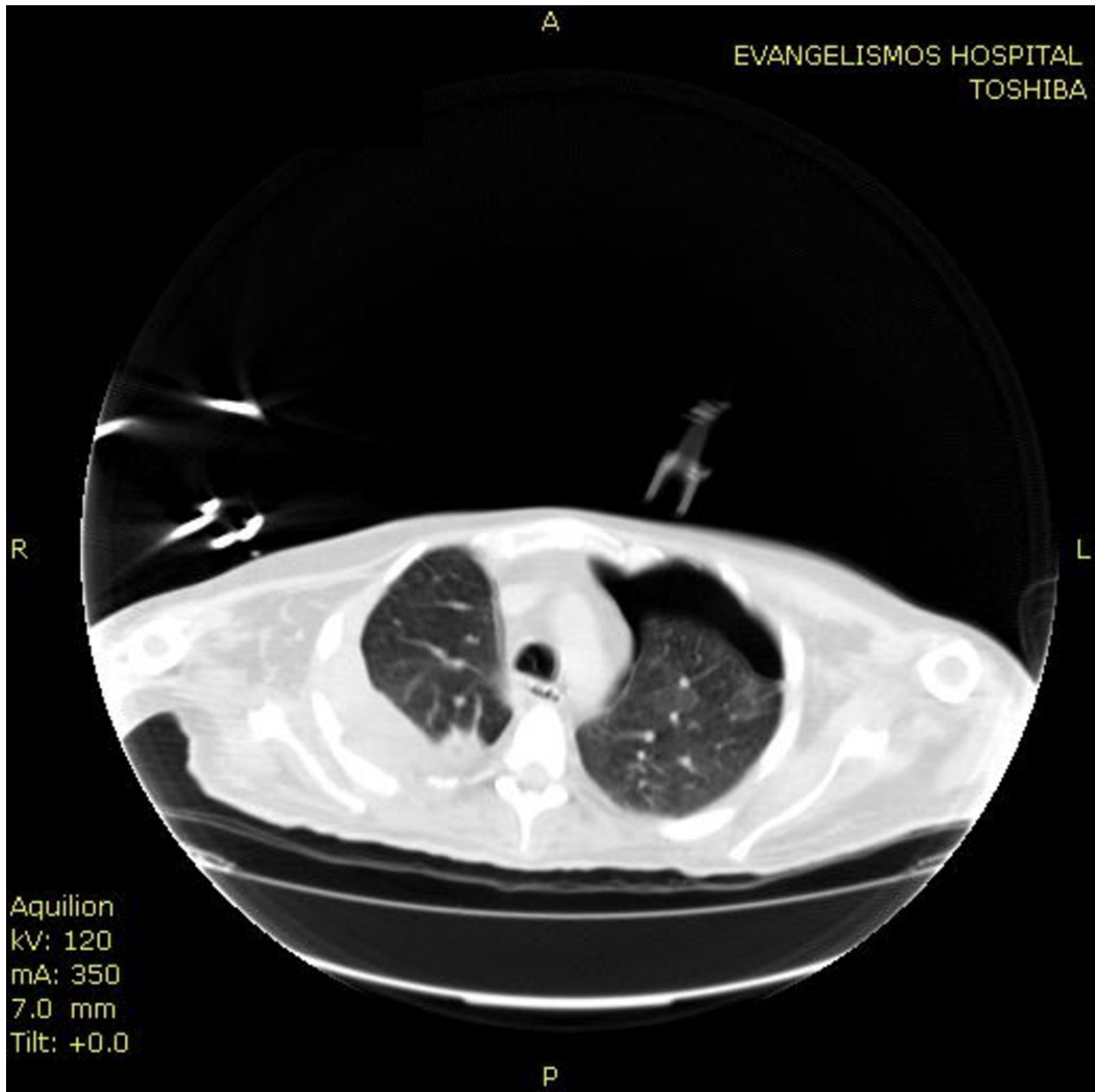


Fig. 8: CT shows left pneumothorax in an ICU patient. CT confirmed the sonographic diagnosis of pneumothorax.

Conclusion

Pneumothorax is a common finding in the critically ill patients. The low sensitivity of the chest X-ray in the diagnosis of pneumothorax and the various difficulties of performing the gold-standard CT, makes US an invaluable method for bedside use in the ICU. Furthermore, lung ultrasonography is a bedside, non-invasive and without radiation technique that can be considered as an attractive and promising alternative to CT in the diagnosis of pneumothorax in the ICU.

Images for this section:



Fig. 1: Evangelismos Hospital, Athens, Greece



Fig. 2: National and Kapodistrian Univesity of Athens

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