Case Report:

Diagnosis and signs of pneumothorax on ultrasound with radiological review.

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Abstract:

Ultrasound (USG) has a higher sensitivity than the traditional standing chest radiography (CXR) for the detection of a pneumothorax. Also supine chest radiographs have shown to have low sensitivity in traumatic pneumothorax. Computed tomography, is a gold standard for the detection of pneumothorax. However it requires patients to be shifted out of the clinical area/ICU. USG when added to the FAST (Focused Assessment with Sonography in Trauma) protocol, can help in rapid evaluation of the chest for the detection of a pneumothorax and can offer pertinent clinical information to aid in the management of the trauma patient with undifferentiated injuries.

Key-words: Pneumothorax, B-mode, M-mode, lung/pleural sliding, sea-shore sign

Introduction:

The use of ultrasound (US) in the diagnosis and treatment of patients is a well-known for many years. Thoracic sonography is a new and evolving method in comparison to other ultrasound applications. Thoracic ultrasound has gained slow acceptance due to the traditional teaching that the air-filled lungs are not ultrasound friendly. Poor imaging is a result of the confinement of air between the lung and the chest wall, preventing diffusion of the ultrasound beam into the parietal pleura and deep lung structures, leading to a production of artifacts.

In the past few decades, bedside lung sonography has developed an established role in literature for the diagnosis of thoracic diseases. This development is based on better understanding of the sonographic artifacts caused by the interplay of air and fluid in the lungs. In 1987, Wernecke et al. first reported the use of ultrasound to detect pneumothorax in humans.1 The Focused Assessment with Sonography in Trauma (FAST) examination has now been modified to include lung imaging as part of the evaluation in a trauma patient and has been renamed as the E-FAST examination, with ‘E’ standing for extended, including the standard lung views.

A pneumothorax can be divided into two broad categories: atraumatic or traumatic (including iatrogenic cause). Atraumatic pneumothorax can further be divided into primary spontaneous or secondary spontaneous. Pneumothorax is commonly associated with blunt and penetrating thoracic injuries and is one of the leading causes of preventable morbidity and mortality. Small- (10% or less) or medium (11 to 40%)-sized pneumothoraces are usually not life-threatening and their management protocol varies.2 However, a delay in the diagnosis and treatment, especially in those who are on ventilatory support systems, may lead to progressive increase in pneumothorax and ultimately result into hemodynamic instability.3
Case history:
A 52 years old male patient came to the casualty with complaints of sudden onset breathlessness and right sided chest pain which was spontaneous in onset. There was no history of trauma. Clinical examination was in favour of pneumothorax. Emergency USG of thorax was done to rule out pneumothorax as the patient could not be shifted for standing radiograph of chest. A 6-11Mhz linear transducer and 2-5 MHz curvilinear transducer was used to obtain ultrasound images of the patient's bilateral chest walls. The probe was placed perpendicular to the ribs along anterior chest wall in mid-clavicular line in first five intercostal spaces and was moved laterally upto mid-axillary line.
B-mode in left hemithorax (normal side) showed presence of ‘lung sliding’ and ‘comet-tail’ artifacts. M-mode revealed normal findings of ‘seashore sign’ (fig. 1). However, USG of right hemithorax (having pneumothorax) revealed absence of ‘lung sliding’ and absence of ‘comet-tail’ artifacts on B-mode and positive “barcode” or ‘stratosphere sign’ (fig. 2) on M-mode. Pneumothorax diagnosed on USG in our case was confirmed on X-ray chest (AP view) (fig. 3).

Discussion:
In 1987, Wernecke et al. first reported the use of ultrasound to detect pneumothorax in humans. USG diagnosis of pneumothorax is on B-mode (brightness mode), M-mode (motion mode) and power Doppler. Primary sonographic signs of pneumothorax include ‘absent lung/pleural sliding’ and ‘presence of stratusphere sign’. Secondary signs of pneumothorax include loss of ‘comet-tail artifacts’, ‘presence of A lines’, ‘the lung-point sign’, ‘The Power slide’ and ‘presence of lung pulse’. The presence of ‘pleural/lung sliding’ is the most important finding in normal aerated lung. It is seen as the hyperechoic pleural line moving or shimmering back and forthin between two ribs. Lung sliding corresponds to the to-and-fro movement of the visceral pleura on the parietal pleura that occurs with respiration. It is a dynamic sign and is identified on ultrasound as horizontal movement along the pleural line.

The use of M-mode, gives the evidence of pleural sliding. It is beneficial in patients where sliding may be subtle, such as, in the elderly patients or patients having poor pulmonary reserve who are not taking large breaths. The M-mode cursor is placed over the pleural line and following pattern is seen on the screen in a normal lung: The motionless part of the chest superior to the pleural line produces horizontal ‘waves’ and the sliding below the pleural layer creates a granular pattern, the ‘sand’. The resultant picture resembles waves crashing onto the sand and is therefore called the ‘seashore sign’. The negative predictive value for lung sliding is reported as 99.2–100%. This indicates that the presence of sliding effectively rules out a pneumothorax. Lung-sliding sign may not be seen in large consolidations, pleural adhesions, pulmonary fibrosis, atelectasis, acute respiratory distress syndrome, right main stem intubation, phrenic nerve palsy.

In a pneumothorax the to-and-fro movement or shimmering of the pleural line will not be present due to presence of air between the two pleural layers. The M-mode tracing in a pneumothorax will thus display only one pattern of ‘parallel horizontal lines’ above and below the pleural line. This pattern resembles a ‘barcode’ and is often called the ‘stratosphere sign’. ‘Comet tail artifacts’ are ‘ray-like’ projections that originate from the pleural line which are created when ultrasound waves hit the interface between the apposing parietal and visceral layers of the pleura.
‘B-lines’ or ‘comet-tail artifacts’ are reverberation artifacts which are seen as hyperechoic vertical lines extending from the pleura to the edge of the screen without fading (fig. 4). In patients with pneumothorax these artifacts are absent because they are created by the visceral pleura which is not seen in pneumothorax due to air between the two pleural layers. There is high negative predictive value for ‘comet tail artifacts’, reported at 98–100%, such that visualization of even one comet-tail essentially rules out the diagnosis of a pneumothorax.7,8

‘A-lines’ are another important artifacts that can be helpful in the diagnosis of a pneumothorax. They are also reverberation artifacts. They appear as equally spaced, repetitive, horizontal hyperechoic lines reflecting from the pleura. The space in between each ‘A-line’ is equal to the distance between the skin surface and the parietal pleura. In the normal patient, these ‘A-lines’ are overshadowed by the presence of ‘B-lines’ which originate from the visceral layer upto the edge of the screen. Thus in patient with pneumothorax ‘B-lines’ will be absent and the ‘A-lines’ will be seen. Absent lung sliding with the presence of ‘A-lines’, the sensitivity and specificity for an occult pneumothorax is as high as 95 and 94%, respectively.7

The ‘lung-point sign’ is seen at the border of a pneumothorax. It is seen due to lung sliding intermittently and coming into contact with the chest wall during inspiration. It serves as a helpful measure in determining the actual size of the pneumothorax. On applying M-mode at this point, alternating ‘seashore’ and ‘stratosphere’ patterns are seen (fig. 5). The ‘lung-point sign’ defines border of pneumothorax is 100% specific.8,9 The location of the lung point can be used in determining the size of the pneumothorax. The more lateral or posterior the ‘lung-point sign’ is seen, the greater is the size of pneumothorax. Thus, if the ‘lung-point sign’ is demonstrated on anterior chest wall, it can be assured that the pneumothorax is relatively small.7,10 It is likely to be large pneumothorax if it is demonstrated in mid-axillary line or along posterior chest wall. This quantification is useful for prognosis and treatment, as large pneumothorax need intervention are more likely to require thoracostomy.7 Though the specificity is high, the sensitivity of the ‘lung-point sign’ is relatively low (reported at 66%) and this sign is not seen in cases of total lung collapse.9

The ‘Power Slide’ refers to the use of power Doppler to demonstrate the lung sliding. Power Doppler is very sensitive and can pick up subtle flow and movement. Power Doppler will show the sliding pleural line as ‘colour flow’ if lung sliding is present. This technique is extremely helpful in detecting subtle sliding where direct visualization may be difficult. However due to increased sensitivity, the disadvantage of this type of Doppler is that the probe needs to be steady and there should not be any patient movement in so as to prevent artifacts and erroneous colour flow over the pleural line, when sliding is actually absent.6,11

The ‘lung pulse’ refers to rhythmic movement of the pleura synchronous with the cardiac rhythm. It is best seen at the pleural line in areas of the lung adjacent to the heart. Lung pulse is not seen in normal well-aerated lung, because lung sliding becomes dominant and resistant to cardiac vibrations. The ‘lung pulse’ is a result of cardiac vibrations being transmitted to the lung pleura in poorly aerated lung. Cardiac activity is essentially detected at the pleural line when there is absent lung sliding.8

Transthoracic USG (B-mode, M-mode and power Doppler) can be used to detect or exclude...
pneumothorax following trauma, without trauma and following interventional procedures like lung biopsy.\textsuperscript{12}

Figure 1: This M-mode image in normal left hemithorax demonstrates a linear, laminar pattern (green arrow) in the tissue superficial to the pleural line (blue arrow) and a granular or ‘sandy’ appearance (red arrow) deep to the pleural line. This phenomenon, known as the ‘seashore sign’.

Figure 2: M-mode image in right hemithorax (having pneumothorax) demonstrates a linear, laminar pattern (green arrow) in the tissue superficial to the pleural line (blue arrow) and a similar linear pattern (red arrow) deep to the pleural line. This phenomenon, known as the ‘stratosphere sign’ or ‘barcode’. B-mode showed absence of lung/pleural sliding sign.

Figure 3: X-ray chest AP view showing right sided pneumothorax.

Figure 4: The green arrow indicates the ‘comet-tail artifact’ or the ‘B-line’ seen as hyperechoic vertical line extending from the pleura to the edge of the screen without fading (seen in normal left hemithorax). B-line is seen in normal chest (without pneumothorax).

Figure 5: Demonstrates the alternating ‘seashore’ (green arrow) and ‘stratosphere’ (red arrow) at the ‘lung point’ on M-mode.
References: