Use of ultrasound to diagnose pneumothorax after video assisted thoracic surgery: Do we need to acquire a new skill?

Surbhi D. Mundada, Kundan S. Gosavi, Bharti Kondvilkar
Department of Anesthesia and Critical Care, Grant Medical College and Sir J.J. Group of Hospitals, Byculla, Mumbai, Maharashtra, India

ABSTRACT

Diagnosis of a pneumothorax in the immediate post-operative area can be difficult. Traditional gold-standard modalities may not be available or feasible to institute. Ultrasound (US) guidance allows the anesthesia provider a method of quickly detecting this potentially life-threatening complication especially when it’s least expected. We encountered such a case when a 40 years male patient posted for video assisted thoracic surgery for drainage of empyema on left side of chest developed pneumothorax on right side post-operatively. Timely diagnosis with the help of US saved time and his life. We thus want to emphasize the importance of this simple but useful skill to the anesthesiologist.

Key words: Anesthesia, diagnosis, pneumothorax, thoracic ultrasonography

INTRODUCTION

The use of ultrasound (US) in the diagnosis and treatment of patients is a well-established modality that has existed for many years. Thoracic sonography is fairly new in comparison to other accepted US applications and is still rapidly evolving. In recent years thoracic US is gaining more attention in critical care, emergency medicine and anesthesia. One important, well-established application is the diagnosis of a pneumothorax. Prompt and accurate diagnosis of a pneumothorax in the management of a patient under anesthesia or recovery can prevent the progression into a life-threatening situation.

CASE REPORT

This was a case report of a 40-year-old male patient with diagnosis of drug resistant aspergillosis empyema thoracis was posted for drainage of empyema by video assisted thoracic surgery. He was a known diabetic on oral hypoglycemic. On pre-operative evaluation he was afibrile with a history of persistent cough. He was a non-smoker with no history of chronic obstructive pulmonary disease. On auscultation air entry was decreased on the left basal region. His investigations were: Hemoglobin 11 g%, Fasting sugars 110 mg%, liver function test and renal function test within the normal limits, chest X-ray (CXR) showed haziness in the left lower lobe, with rest of lung shadow seemingly normal. Electrocardiogram showed no abnormality. Computed tomography (CT) thorax showed loculated consolidation in the left lower lobe with mild pleural effusion. His baseline arterial blood gas showed a pH of 7.48, PO$_2$ of 70 mm Hg, PCO$_2$ 35 mm Hg.

On day of surgery his vitals were — heart rate 90/min, blood pressure (BP) 140/80 mm Hg, SPO$_2$ 97%. After attaching monitors an 18G intravenous (i.v) cannula was secured. He was premedicated with injection glycopyrolate 0.2 mg i.v, injection midazolam 1 mg i.v, injection fenatanyl 100 mcg i.v, injection ondansetron 4 mg i.v. He was induced with injection propofol and injection vecuronium was given for intubation and maintenance. As lung isolation was required a 36 no. double lumen tube was placed in the right bronchus.
without any difficulty. Air entry was checked after inflation of tracheal and bronchial cuffs confirming correct placement of the tube before and after placing the patient in right lateral position. The surgeon then inserted the thoracoscope and performed aspiration of empyema. The peak airway pressure was 30 cm of H_2O and EtCO_2 40 mm Hg throughout the procedure. The surgery took an hour with minimal blood loss. At the end patient was turned supine and reversed using injection neostigmine and injection glycopyrolate. He was extubated after confirming train-of-four of 90%. In the recovery room, patient was put on nasal prongs and pulse oximeter was attached. After 10 min patient became visibly tachypneic and his saturation dropped to 90%. Ventimask with high flow of oxygen was given to the patient but within another 10 min Spo_2 dropped to 80%. His pulse rose to 140/min, BP was 110/70 mm Hg with decreased air entry on right side as compared to left. He was immediately shifted to surgical intensive care unit (ICU) that was in the same building and put on continuous positive air pressure mask with 100% O_2. This helped in gradually bringing up his saturation to 95% but patient was still tachypneic. A CXR was ordered for, but being in government institute delays in bringing the portable machine and technician is inevitable. Hence we decided to diagnose it on US as it was available in our ICU. Using the straight linear array high frequency probe (5-13 MHz) in B-mode we were able to see normal “lung sliding” on left side, but it was absent on the right. “Comet tails” were also not present. On imaging on M-mode there was absence of “seashore sign” in the midclavicular, anterior axillary and mid axillary lines. Hence we concluded the presence of pneumothorax on the unoperated right side. Surgeons were informed immediately and things kept ready for intercostal drainage (ICD) insertion. Luckily for us the X-ray technician also arrived and we were able to also take a CXR for documentation [Figure 1]. After ICD insertion the patient’s tachycardia and tachypnea settled down and he maintained Spo_2 of 96% on nasal prongs. He was shifted toward the next day.

DISCUSSION

The use of US in the diagnosis and treatment of patients is a well-established modality that has existed for many years. Thoracic sonography is fairly new in comparison to other accepted US applications and is still rapidly evolving. The first reported use of US to detect pneumothorax in humans was by Wernecke et al., in the year 1987. 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. The application 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: Traumatic (including iatrogenic) or atraumatic. Atraumatic pneumothorax can further be categorized as primary spontaneous or secondary spontaneous. We suspect spontaneous rupture of bulla in right ventilated lung as the cause in our case. The diagnosis of a pneumothorax is usually made with a combination of clinical signs and symptoms, which may be subtle and plain chest radiography. Regardless of its presentation, the early detection and treatment of a pneumothorax is critical. A delay in the diagnosis and treatment, especially in those who are mechanically ventilated, may lead to the progression of a pneumothorax and resultant hemodynamic instability. In these critical situations where a subtle pneumothorax may be missed, a quick bedside lung US may expedite the diagnosis and treatment of a patient who may have otherwise decompensated.

Several studies highlight the utility of US compared with CXR for the diagnosis of pneumothorax in the Emergency Department. The sensitivity of US in certain studies has been similar to that found in CT scan, which is still considered to be the gold standard for the detection of a pneumothorax. Lichtenstein and Menu have shown that US has a sensitivity of 95.3% and a specificity of 91.1% for detecting pneumothorax in ICU patients. One recent article demonstrated impressive success rates of pre-hospital medical personnel being trained quickly to identify a pneumothorax on US. This suggests that other providers can be trained to quickly perform ultrasonographic scanning and to recognize a suspected pneumothorax with sonography. Other advantages include omission of radiation exposure to the staff and patient, reduction in cost, completion of diagnosis without the need for a radiologist (e.g., late-night care in tertiary facilities) and ease of use. Following are the highlights of US diagnosis of pneumothorax.

**Figure 1:** Chest X-ray showing pneumothorax on right side
Probe selection and equipment

The bedside sonographic diagnosis of pneumothorax can be performed with most portable US machines without the need of any sophisticated functions. A straight linear array high frequency probe (5-13 MHz) may be most helpful in analyzing superficial structures such as the pleural line and providing better resolution.

Technique and normal anatomy

A pneumothorax will rise to the least dependent area of the chest. In a supine patient this area corresponds to the anterior region of the chest at approximately the second to fourth intercostal spaces in the mid-clavicular line. This location will identify the majority of significant pneumothoraces in the supine patient. On the other hand, air will accumulate in an apicolateral location in an upright patient.

The probe is placed (with indicator pointing cephalad) between two ribs. The presence of pleural sliding is the most important finding in normal aerated lung in the B-mode. The sonographer should visualize the hyperechoic pleural line in between two ribs moving or shimmering back and forth. “Comet-tail artifacts” are reverberation artifacts that appear as hyperechoic vertical lines that extend from the pleura to the edge of the screen without fading. “Comet-tail artifacts” move synchronously with lung sliding and respiratory movements. “A-lines” are other important normal thoracic artifacts that can help in the diagnosis of a pneumothorax. These are also reverberation artifacts appearing as equally spaced repetitive horizontal hyperechoic lines reflecting off of the pleura. The space in between each A-line corresponds to the same distance between the skin surface and the parietal pleura [Figure 2a].

In the M-mode cursor is placed over the pleural line and two different patterns are displayed on the screen: The motionless portion of the chest above the pleural line creates horizontal “waves,” and the sliding below the pleural line creates a granular pattern, the “sand” [Figure 2b]. This is called “sea shore sign” and is present in normal lung.

Sonographic signs of pneumothorax

In a pneumothorax, there is air present that separates the visceral and parietal pleura and prevents visualization of the visceral pleura. In this situation, lung sliding is absent. The resultant M-mode tracing in a pneumothorax will only display one pattern of parallel horizontal lines above and below the pleural line, exemplifying the lack of movement. This pattern resembles a “barcode” and is often called the “stratosphere sign” [Figure 2c].

The negative predictive value for lung sliding is reported as 99.2-100%, indicating that the presence of sliding effectively rules out a pneumothorax. “Comet-tail” artifacts are generated by the visceral pleura, are not visualized in a pneumothorax, therefore, these artifacts are not generated. The negative predictive value for this artifact is high, reported at 98-100%. The “lung-point sign” occurs at the border of a pneumothorax. It is due...
to sliding lung intermittently coming into contact with the chest wall during inspiration and is helpful in determining the actual size of the pneumothorax. This sign can further be delineated using M-mode where alternating “seashore” and “stratosphere” patterns are depicted over time. The “lung-point sign” is 100% specific for pneumothorax and defines its border.\(^{[11]}\)

**CONCLUSION**

Until now, US has been a perfect modality in critical care setting for performing certain procedures placement of a central line. The advantages of ultrasonography in diagnosing pneumothorax show tremendous value to anesthesia providers for its use in the operating room, recovery and surgical ICU. It has also been found to be beneficial in the post-intubation scenario, where a confirmation of bilateral lung sliding rules out a right main stem intubation. Incorporating it into anesthesia practice seems prudent and beneficial so that many critical events can be diagnosed early thus decreasing morbidity and mortality.

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