Ultrasound diagnosis of pneumothorax after Fine Needle Aspiration of the lung

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Purpose

The aim of this study was to prospectively evaluate the accuracy of transthoracic sonography in the detection of pneumothorax in patients who previously had undergone CT guided lung biopsy with fine needle aspiration (FNA).
Methods and Materials

PATIENTS

From May 2010 to March 2011, 35 patients who previously had undergone a CT guided lung FNA, underwent transthoracic sonography for the detection of pneumothorax.

The reason of the lung FNA in all cases, was to achieve a sample (cytology) for the pathological diagnosis of a lung mass, previously seen on a routine CT exam.

35 patients were enrolled in this prospective study: 28 men, 7 women; age range, 30-84; median age, 69.5 years. All of them were outpatients.

The study protocol followed the guidelines of our local ethics committee, and informed consent was obtained from all patients.

STUDY DESIGN

CT guided lung FNA was performed by two radiologists with wide experience in lung biopsies. As reference, in our institution, the pneumothorax rate seen in the chest X-ray, performed 3h. after CT guided lung FNA, is 16.7%, based on a study of 276 patients. The biopsy was performed with the patient in supine or prone, depending on the lesion approach. FNA was performed by a coaxial system, using a 19-gauge, 9 cm long needle and the sample was obtained with a 20-gauge, 12cm long needle.

After CT guided lung FNA procedure, the patient was admitted to the Day Hospital Unit and a chest X-ray was done 3h later, to assess the presence of pneumothorax, bleeding or other complications. Prior to chest X-ray examination, a transthoracic sonography was performed.

All sonographic examinations were performed by two radiologists well trained in chest ultrasound. Always, two independent physician without contact between them, were in charge of the CT guided lung FNA and posterior transthoracic sonography. The radiologist in charge of the sonographic examination, ignored the presence/absence of pneumothorax.

A real-time sonographic system with a low-frequency convex transducer (3MHz, Logic 7, General Electric) was used for a good tissue penetration through the chest wall, into the lung parenchyma. A high frequency linear probe (10-12 MHz) was used for the analysis of the pleural line.
Transthoracic sonography was performed as a systematic examination of 2 zones of the chest (6 thoracic quadrants), starting from the biopsy site. The anterior zone is bound by the sternum, clavicle, and anterior axillary line (divided into 4 quadrants). The lateral zone is bound by the anterior and posterior axillary lines (divided into 2 quadrants).

![Systematic study of thoracic quadrants after lung biopsy for pneumothorax diagnosis. The anterior (LAA) and posterior (LAP) axillary lines delineate the anterior and lateral areas, divided into six quadrants. Anterior area: 1-4 quadrants. Lateral area: 5 and 6 quadrants. For the complete lung exam, images from each zone were evaluated. Using a systematic analysis, pneumothorax can be confidently detected.](image)

**Fig. 1:** Systematic study of thoracic quadrants after lung biopsy for pneumothorax diagnosis. The anterior (LAA) and posterior (LAP) axillary lines delineate the anterior and lateral areas, divided into six quadrants. Anterior area: 1-4 quadrants. Lateral area: 5 and 6 quadrants. For the complete lung exam, images from each zone were evaluated. Using a systematic analysis, pneumothorax can be confidently detected.

**References:** Department of Radiology, Hospital Marqués de Valdecilla, Santander, Spain 2013

As 98% of significant pneumothoraces are at the anterior and inferior area in supine patients [1], as a matter of time and characteristics of our patients, anterior and lateral zones were scanned.

The following parameters were assessed to diagnose or exclude postbiopsy pneumothorax: Lung Sliding, A and B lines and Lung Point.
The boundary between visceral pleura and lung surface is visualized with transthoracic sonography as an echoic line, the pleural line. **Lung sliding** is a dynamic twinkling respiration-dependent movement, visible at the pleural line. It corresponds to the displacement of the pleural line with respect to the parietal pleura and chest wall, seen under real-time conditions (Fig. 2 on page 13) [2]. Presence of lung sliding rules out pneumothorax, because its negative predictive value is 100%, with a 100% sensitivity [3].

**Fig. 2**: The pleural line indicates the lung surface, represented in the video as an echoic line, corresponding to the displacement of the lung throughout the chest, synchronized with respiration movement. Lung sliding allows pneumothorax to be confidently discounted, in few seconds, because its negative predictive value is 100%, with a 100% sensitivity.

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**Absent lung sliding** is a basic and initial step for diagnosing pneumothorax. Consists on a striking absence of motion arising from the pleural line, instead of the physiological lung sliding (Fig. 3 on page 14). Is extremely frequent in critically ill patients, even though we studied outpatients. Absent lung sliding does not mean pneumothorax; is not
enough for the diagnosis, however, combining it with other signs, the effectiveness of ultrasound is improved.

**Fig. 3:** In contrast to previous video, now there is no movement of the pleural line along the thoracic wall. The result is an absent lung sliding. Absent lung sliding is a basic and initial step for the pneumothorax diagnosis.

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The basic normal artifact arising from pleural line, is a horizontal repetition of the pleural line recurring at regular intervals, the **A-line** (Fig. 4 on page 15).
Fig. 4: The A lines are horizontal lines (arrows) that arise from the pleural line (arrowhead) and are displayed at regular intervals with clinical applications for pneumothorax detection.

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The A-line sign, which is 100% sensitive for the diagnosis of pneumothorax [4], is in no case specific as the A-lines are also generated by physiologic air. When abolishing lung sliding and the A-line sign are combined (Fig. 5 on page 16), Linchestein et al. found a sensitivity of 100% and a specificity of 96% for pneumothorax [4].
**Fig. 5:** In this video the previously described lung sliding abolition and A-lines are combined. When these 2 signs coexist, the sensitivity and specificity for pneumothorax detection reaches almost 100%.

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**B lines** are comet-tail artifacts which become visible when a marked difference in acoustic impedance exists between an object and its surroundings. These artifacts are evoked only at the boundary between the visceral pleura and the aerated lung [5, 6]. These comet tail artifacts are sporadic in healthy lung (Fig. 6 on page 17) and more numerous in diffuse parenchymal disease (Fig. 7 on page 18). The point, is that the slightest B line allows ruling out pneumothorax [4].
**Fig. 6:** B line. 61 year-old man who previously had undergone right hemithorax lung biopsy. A sonographic examination was performed 3h after the procedure. A B-line (arrow), perpendicular and synchronous with pleural line movement, reflected a normally aerated lung and ruled out pneumothorax. These comet tail artifacts are sporadic and isolated in healthy lung, in the inferolateral chest wall.

**References:** Department of Radiology, Hospital Marqués de Valdecilla, Santander, Spain 2013
Fig. 7: B-lines. 69 year-old man refered to thoracic sonography after lung biopsy. Thoracic ultrasonography showed an irregular echogenic pleural line, which appeared discontinuous due to a lung mass infiltrating the pleura. Numerous B-lines (arrows) are seen, because ultrasound beam can be transmitted through the pathologic interstitium. These artifacts allow ruling out pneumothorax.

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When pneumothorax is diagnosed on the basis of the absence of the lung sliding sign and B lines and the presence of A lines, the lung point, defined as the border between aerated lung and pneumothorax [7], is assessed (Fig. 8 on page 19 and Fig. 9 on page 20).
Fig. 8: Lung point. In this CT image, the sonographic probe illustrates the theoretical chest location, in the supine patient, of the lung point. At this point, US findings of pneumothorax are shown in the next video.

References: Department of Radiology, Hospital Marqués de Valdecilla, Santander, Spain 2013
**Fig. 9**: Lung Point. With the probe placed at the location shown in previous image, lung point appears as a dynamic image containing both normal and pneumothorax findings with a specificity of 100%.

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Taking as Gold Standard for the diagnosis of pneumothorax, the CT for the previously performed lung FNA, ultrasound findings were correlated to confirm the presence/absence of pneumothorax. Since minimal postbiopsy changes are always seen in the biopsy region of the pleura, to be considered as a case of pneumothorax, at least, a clearly visible interpleural air layer was necessary to be visualized in CT. CT findings of a <2mm non-laminar interpleural air, was not considered as pneumothorax.
Fig. 1: Systematic study of thoracic quadrants after lung biopsy for pneumothorax diagnosis. The anterior (LAA) and posterior (LAP) axillary lines delineate the anterior and lateral areas, divided into six quadrants. Anterior area: 1-4 quadrants. Lateral area: 5 and 6 quadrants. For the complete lung exam, images from each zone were evaluated. Using a systematic analysis, pneumothorax can be confidently detected.

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Results

From the 35 patients referred to a transthoracic ultrasound after the CT guided lung FNA, 18 (51.4%) presented pneumothorax and 17 (48.6%) had no pneumothorax.

None of the patients necessitated chest tube insertion or drainage. All patients with pneumothorax were discharged on the same day after the procedure.

Transthoracic sonography correctly depicted all cases of pneumothorax and excluded pneumothorax in the other cases.

In all patients with pneumothorax, transthoracic sonography showed absence of lung sliding and B lines and presence of A lines.

The lung point was identified in 10 out of 18 cases of pneumothorax (55.6%).

The sensitivity, specificity, positive predictive value, negative predictive value, and overall accuracy of transthoracic sonography were 100%. Thus, there was 100% concordance with CT (Gold Standard) findings.

In one case, the presence of a <2mm. non-laminar interpleural air layer in the CT was dismissed, and therefore was not considered as pneumothorax. The subsequent chest ultrasound was reported as absence of pneumothorax.

The average scan time for the thoracic ultrasound was 5 minutes. The average room occupation time was 11 minutes.
Conclusion

These preliminary results suggest that sonographic diagnosis of pneumothorax is an accurate, rapid, non invasive and simple technique in the detection of pneumothorax after CT guided lung biopsy and can be useful for monitoring pneumothorax after lung biopsy.
References


