Incidence and Risk Factors of Delayed Pneumothorax After Transthoracic Needle Biopsy of the Lung*

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Study objectives: To evaluate the incidence and clinical significance of delayed pneumothorax, and to analyze the influence of multiple variables on the rate of delayed pneumothorax associated with transthoracic needle biopsy (TTNB) of the lung.

Study design: Prospective study.

Setting: Tertiary care university hospital.

Study subjects: Adult patients underwent TTNB from June 2001 to June 2002.

Measurements and results: Among the 458 patients included in this study, 280 fluoroscopic-guided, 21 CT-guided, and 157 ultrasonography-guided lung biopsies were performed. A follow-up chest radiograph was obtained immediately, and 3 h, 8 h, and 24 h after the biopsy procedure. Pneumothorax that had not developed up to 3 h but developed later was defined as a delayed pneumothorax. Patients with a symptomatic or enlarged pneumothorax were treated using a pigtail catheter or chest tube. Variables such as age, gender, lesion size, location, presence of an emphysematous change, biopsy guidance methods, and biopsy devices were analyzed. Pneumothorax developed in 100 of the 458 patients (21.8%), and delayed pneumothorax developed in 15 patients (3.3%). Seventeen patients, including 3 patients with delayed pneumothorax, required a pigtail catheter or a chest tube insertion. The pigtail catheter or chest tube insertion rate in delayed pneumothorax was 20% (3 of 15 patients). Female gender and the absence of an emphysematous change correlated with an increased rate of delayed pneumothorax (p < 0.05). Lesion size, location, biopsy guidance methods, devices, and underlying diseases were not correlated with the delayed pneumothorax rate.

Conclusions: The incidence of delayed pneumothorax was 3.3% of all TTNBs. Female gender and the absence of an emphysematous change were identified as risk factors for delayed pneumothorax. Delayed pneumothorax is clinically important because of its considerable incidence and the necessity for pigtail catheterization or chest tube insertion in these patients.

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Key words: complication; delayed pneumothorax; emphysema; transthoracic needle biopsy of lung

Abbreviations: PA = posteroanterior radiograph; PACS = picture archiving and communication system; TTNB = transthoracic needle biopsy

Transthoracic needle biopsy (TTNB) of the lung is a well-established and effective method for obtaining pulmonary tissue for pathologic examination.1–3 Although it is generally a safe and well-tolerated procedure, pneumothorax is a relatively common and there are potentially serious complications.

The reported incidence of pneumothorax as a complication of TTNB varies widely from 8 to 61%, with a 10.4 to 17.4% chest tube insertion rate.1,2,4,5 Because pneumothorax usually occurs immediately, a further 9% are detected by chest radiography 1 h after biopsy, and an additional 2% are detected at 4 h.4,6 Early hospital discharge after TTNB has been recommended by previous studies.7–9 However, it is not well known how often pneumothorax presents as a late complication. The reported incidence of delayed pneumothorax varies from 1.4 to 4.5%.8–10
Therefore, operators’ concerns about potential delayed pneumothorax have led some clinicians to request postprocedure chest radiographs.11

Our institute has performed TTNB on inpatients for a long time, and we have found that delayed pneumothorax is not a rare event. Therefore, we performed this prospective study to analyze the incidence, risk factors, and clinical significance of delayed pneumothorax.

**Materials and Methods**

**Study Design**

From June 2001 to June 2002, we conducted a prospective study of 458 patients who underwent TTNB. Two hundred eighty patients (61.1%) were performed with fluoroscopic guidance, 210 (46%) with CT guidance, and 157 (34.3%) with ultrasonographic guidance. Coaxial procedures were performed with an 18-gauge TSK gun (TSK Laboratory; Tochigi, Japan). A biopsy of a peripheral lesion was often performed directly using a 22-gauge needle (Westcott needle; Medical Device Technologies; Gainesville, FL).

The procedure was performed with the patient in a prone, supine, or lateral decubitus position, depending on the location of the lesion. Pleural effusions, fissures, and bullae were avoided during biopsy if possible.

After biopsy, all patients were placed in the decubitus position to compress the biopsy site. To confirm the occurrence of pneumothorax, chest posteroanterior radiographs (PAs) using a digital imaging system and displayed by a picture archiving and communication system (PACS) were obtained immediately, and 3 h, 8 h, and 24 h after TTNB in the erect position. The presence of pneumothorax was thoroughly investigated by using a magnifier on the PACS. If the patient complained of symptoms related with possible complications (pneumothorax or hemoptysis), a chest PA was obtained. If pneumothorax was detected on later chest PAs, previous chest PAs were scrutinized for previously undetected pneumothorax using the PACS magnifier.

**Data Analysis**

Demographic information including patient’s age and gender, lesion size and location, number of pleural punctures, types of devices used, and the presence or absence of emphysematous change in same lobe in which biopsy was obtained were analyzed. The presence of any type of emphysema in the lobe in which biopsy was performed was determined by high-resolution chest CT imaging in all patients. All chest radiographs and chest CTs were examined by at least one radiologist and one pulmonologist, and all complications including pneumothorax, the necessity for catheter insertion, and accompanying symptoms were recorded.

Pneumothorax that developed >3 h after TTNB was defined as delayed pneumothorax. Pneumothorax that developed immediately or up to 3 h after TTNB was defined as an early pneumothorax. Patients with stable, asymptomatic pneumothorax were closely observed with oxygen inhalation. Patients with a large pneumothorax underwent immediate needle aspiration. The indications for catheter insertion were as follows: (1) a large pneumothorax (>35% apical or when smaller with a larger with a smaller thoracic component extending below the level of the hilum), (2) progressive pneumothorax (increasing in size on following radiographs indicating a continuous leak), and (3) symptomatic patients (severe pain or dyspnea).

**Results**

**Characteristics of Study Population and Diseases**

Four hundred fifty-eight patients (279 men and 179 women) were included in the study. Mean patient age was 59 years (range, 19 to 90 years). The average lesion diameter was 3.31 cm (range, 0.5 to 11.0 cm). Four hundred nine patients had no visible emphysematous change by chest CT, and 70 patients showed emphysematous change in the same lobe of the lesion. Table 1 summarizes the demographic data and multiple variables in the 458 patients.

**Incidence and Characteristics of Pneumothorax**

Pneumothorax occurred in 100 of the 458 patients (21.8%). Delayed pneumothorax was found in 15 cases (15% of pneumothorax and 3.3% of total procedures). Three of the 15 cases (20%) of delayed pneumothorax required chest tube placement.

Female gender was found to be related to delayed pneumothorax. Of the 458 patients, 179 were women and 279 were men. Delayed pneumothorax occurred in 10 of the 179 female patients and in 5 of the 279 male patients (p = 0.046), and this gender difference was statistically significant. However, female gender was not a risk factor for the development of early pneumothorax (p > 0.05). The lesion size in patients with delayed pneumothorax (2.47 ± 1.14 cm [mean ± SD]) was significantly smaller than in patients without pneumothorax (3.46 ± 1.87 cm) (p < 0.05), and lesion size in patients with early pneumothorax was also significantly smaller than in patients without pneumothorax (p < 0.05). No difference in lesion size was found between early and delayed pneumothorax. Therefore, a small lesion was identified as a risk factor of early and delayed pneumothorax.

Fine-needle aspiration biopsy (22-gauge Westcott needle) was performed in 417 procedures (91.0%), gun biopsy (18-gauge TSK gun) was performed in 14 procedures, and both fine-needle aspiration biopsy and gun biopsy were performed in 27 procedures (5.9%). The use of a larger (18-gauge) needle was not found to be a significant risk for pneumothorax compared with the smaller (22-gauge) needle.

Another important risk factor was the presence of emphysematous change in the same lobe. The presence of emphysematous change was identified as a
definite risk factor of pneumothorax (p < 0.005): 26 pneumothoraces (53.0%) among 49 emphysematous lungs vs 74 pneumothoraces among 409 nonemphysematous lungs.

Interestingly, emphysematous lung was not observed in the 15 delayed pneumothorax cases, compared with 26 emphysematous lungs (30.5%) in 85 cases of early pneumothorax (p < 0.01). In other words, all cases of delayed pneumothorax developed in a lung without emphysematous change. Therefore, the absence of an emphysematous change was identified as a risk factor of delayed pneumothorax as compared with early pneumothorax.

In patients with pneumothorax, the frequency of chest tube placement was not significantly different (16.5% in early and 20% in delayed pneumothorax). The time to detect delayed pneumothorax varied from 5 to 120 h. Six patients (40%) with delayed pneumothorax complained of chest symptoms at the time of chest PA; however, no symptoms developed in 60% of the patients with delayed pneumothorax. Three of the six symptomatic patients underwent catheter placement. The time to catheter insertion in delayed pneumothorax varied from 56 to 120 h (Table 2; Fig 1, 2).

In one 75-year-old patient (Table 2; case 3), mild dyspnea developed at 17 h after TTNB, and no evidence of pneumothorax was found by chest PA at 24 h. The patient received oxygen therapy only up to 120 h, until pneumothorax was detected with increasing dyspnea (Fig 2). This symptom was due to a total left pneumothorax and a hemothorax not visible on earlier chest radiographs. This patient required chest tube insertion and emergent bronchial arterial embolization due to massive bleeding in the pleural cavity.

**Discussion**

TTNB of the lung has proven to be an extremely useful procedure for the evaluation of a variety of lung diseases, and the most common and potentially serious complication of TTNB is pneumothorax. The reported incidence of pneumothorax as a
complication of percutaneous lung biopsy varies widely from 8 to 61%, with a 10.4 to 17.4% chest tube insertion rate.\(^1,2,4,5\)

It has been estimated that most cases of pneumothorax occur within 30 min of the procedure, and that some with a small leak may not become evident for 3 h or 4 h.\(^4,6\) In a study by Perlmutt et al\(^4\) of 673 patients who underwent percutaneous TTNB, no pneumothoraces developed 4 h after the procedure, and it was recommended that chest radiographs be obtained at 1 h and 4 h after biopsy in outpatients. Therefore, TTNB is routinely performed as an outpatient procedure.\(^7,9,12\) Stevens and Jackman,\(^7\) based in their experience of performing a large series of TTNBs in an outpatient setting, found that pneumothorax rarely became apparent after the first hour of observation. Dennie et al\(^9\) concluded that early discharge (30 min) after lung biopsy in the absence of pneumothorax was a safe approach to outpatient TTNB.

However, it is not well known how often pneumothorax presents as a late complication. The reported incidence of delayed pneumothorax varies from 1.4 to 4.5%.\(^8–10\) The substantial incidence of delayed

Figure 1. Delayed pneumothorax (case 2). Left, A: Chest PA obtained 3 h after TTNB. No evidence of pneumothorax was found. Right, B: Chest PA obtained 57 h after TTNB. A large pneumothorax on right lung and shifting of mediastinal structures were found. A chest tube was inserted to relieve dyspnea.

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Gender/Age, yr</th>
<th>Lesion Size, cm</th>
<th>Lobe</th>
<th>Emphysema</th>
<th>Guidance Methods</th>
<th>Device</th>
<th>Diagnosis</th>
<th>Symptom Onset, h</th>
<th>Chest Tube Insertion, h</th>
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Pneumothorax and the potential hazards of undetected pneumothorax lead some clinicians to request postprocedure chest radiographs for > 4 h. Traill and Gleeson reported two patients who acquired pneumothorax > 24 h after CT-guided TTNB; the pneumothorax required treatment in both cases. Delayed pneumothorax has been also reported as a complication of transbronchial lung biopsy, and of subclavian vein catheterization.

Our prospective study shows that the delayed pneumothorax rate was 3.3% (15 of 496 procedures) in 458 patients who underwent biopsy. The development of pneumothorax after TTNB has been attributed to a number of factors, including the lesion size and the location and presence of emphysema. Cox et al. found that a smaller lesion size and emphysema were strongly correlated with the occurrence of pneumothorax, and used thin-section CT to determine if emphysema was visible in the lobe in which the biopsy was performed. We also found a significantly higher (p < 0.001) risk of early pneumothorax in patients with emphysema. In contrast, the absence of an emphysematous change was found to be a risk factor of delayed pneumothorax. In patients with emphysema, the disruption of dilated air spaces and the lack of elastic recoil may prevent rapid sealing of the air leak. Because pneumothorax occurs more quickly in patients with emphysema, delayed pneumothorax rarely develops. However, the elastic recoil of the normal lung parenchyma and pleura over the lesion may seal the small opening of the pleura initially to prevent early pneumothorax. Thus, the later weakening of elastic recoil may facilitate delayed pneumothorax.

The strong correlation between the pneumothorax rate and lesion size is difficult to explain, although this correlation has been previously reported. A possible explanation for this finding is that the up-and-down movement of the needle tip during aspiration biopsy results in more tearing of adjacent lung parenchyma when the lesion is relatively small.

Every patient undergoing this procedure should be warned of the importance of seeking medical attention should increased breathlessness or chest pain develop, and urgent chest radiographic examinations should be performed in all patients with acute respiratory symptoms. We detected three cases of significant delayed pneumothorax requiring immediate chest tube insertion. They were detected at 56 h, 57 h, and 120 h after TTNB, respectively, and showed no evidence of pneumothorax on a 3-h postprocedure radiograph. The relation between TTNB and pneumothorax is not clear, but the lack of other risk factors strongly suggests a causal relationship.

The reason and mechanism of the delayed presentation of pneumothorax is not clear. We reviewed the clinical records of the patients with delayed pneumothorax, and we were unable to find any procedure, such as pulmonary function testing, contributing to pneumothorax. Six patients (40%) with delayed pneumothorax were symptomatic (dyspnea, cough, chest pain); however, it was not clear whether these symptoms were the cause or the result of the delayed pneumothorax.

Because some patients had a history of sudden exertion or coughing prior to the onset of symptoms, delayed pneumothorax might be related to the dis-
placement of small pleural blood clots formed after the biopsy procedure. Pneumothorax could have occurred after fibrinolysis,14 and delayed pneumothorax may have been caused by a slow pleural air leak associated with the insertion.15,16,18

In summary, the incidence of delayed pneumothorax was 3.3% among all percutaneous lung biopsies. Delayed pneumothorax was more frequent in female patients and in underlying normal lung parenchyma in contrast to early pneumothorax. This condition is clinically significant, because 20% of patients with delayed pneumothorax required pigtail catheterization or chest tube insertion. Although the incidence of delayed pneumothorax is low, it is potentially life threatening, and a high index of suspicion is required to properly diagnose and treat this reversible condition. Most cases of delayed pneumothorax occur within 24 h, however, delayed pneumothorax developed after 24 h in 3 of our 15 delayed pneumothorax cases. So we advise patients to bear in mind the possibility of pneumothorax, and to visit the emergency department if dyspnea develops. In addition, we recommend that a chest PA be obtained up to 24 h after TTNB.

REFERENCES
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