

Three-step Needle Withdrawal Method: A Modified Technique for Reducing the Rate of Pneumothorax after CT-guided Lung Biopsy

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Background: Computed tomography (CT)-guided transthoracic needle biopsy is reliable and has become popular for diagnosing pulmonary lesions. Pneumothorax is the most common complication of transthoracic needle biopsy. The aim of this study was to report our preliminary experience with a three-step needle withdrawal technique for CT-guided lung-biopsy, with emphasis on reduction of the pneumothorax rate.

Methods: A total of 146 patients (85 men and 61 women; mean age, 66.1 years; age range 19-91 years) with a pulmonary lesion underwent single slice CT-guided lung biopsy. We used a 17-gauge coaxial needle for guidance and a 18-gauge cutting needle to perform the biopsy. We used a three-step method to withdraw the needle. Images were reviewed to assess the patients' posture and the size, location, and depth of the tumor. Any pneumothorax or chest tube usage was noted.

Results: Pneumothorax occurred in 23 (15.8%) patients, two of whom underwent chest-tube insertion. All 23 patients with a lesion deeper than 4 cm deep had a pneumothorax. In all patients with pneumothorax, lesions were smaller than 2 cm.

Conclusions: Our modified CT-guided lung biopsy method with a three-step needle withdrawal technique appears effective with a relatively low pneumothorax rate. Predictors of pneumothorax in our study were a lesion deeper than 4 cm and a lesion smaller than 2 cm.

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Key words: biopsy complications, computed tomography, lung biopsy, pneumothorax, technology

Computed tomography (CT)-guided transthoracic needle biopsy has become popular for diagnosing pulmonary lesions and is a reliable diagnostic method. CT can provide transverse images of the chest and therefore permits easy and precise localization and calculation of the depth of the lung and mediastinal lesions to be sampled. Pneumothorax is

the most common complication of transthoracic needle biopsy. The reported incidence is 12-36% in most large series, and 11-15% of patients require chest-tube placement.⁽¹⁻⁵⁾ Several authors have suggested auxiliary measures to lower the prevalence; examples include positioning precautions and a blood-patch technique.^(1,2) We reported our preliminary

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experience using a modified CT-guided lung-biopsy technique in an attempt to reduce the pneumothorax rate.

METHODS

The population for this retrospective study included 146 patients with a pulmonary lesion who were examined between January 2000 and December 2005 at Taipei Medical University Hospital, Taiwan. All subjects gave informed consent before their participation, and the Ethics Committee of Taipei Medical University Hospital approved the study.

Four radiologists performed all lung-biopsy procedures with single slice CT guidance (High-Speed; GE Medical Systems, Milwaukee, WI, U.S.A.). During the procedure, we first located the lesion and measured its depth, which was defined as the distance from the pleura to the lesion. Patients were placed in the supine or prone position according to the location of the lesion.

We used a 17-gauge coaxial needle to puncture the lesion as accurately as possible in one attempt. The inner needle was withdrawn, and an 18-gauge cutting needle (Temno; Bauer Medical, Clearwater, FL, U.S.A.) was placed to obtain a sample (Fig. 1).



Fig. 1 The cutting needle punctures the lesion for sampling.

According to the location of the cutting needle, we divided the lesion into quadrants. The biopsy was done 3 times at angles of 0°, 90°, and 180°.

We used a three-step method to withdraw the needle. In the first step, the inner needle was pulled back with its tip still in the sheath of the outer needle. It was then slowly withdrawn until it was about 5 mm beneath the visceral pleura (which faces the parenchyma) (Fig. 2). The inner needle was held in this position for 2-3 minutes. In the second step, the needle was withdrawn further until it just reached the parietal pleura (which faces the chest wall). It was then held there for 2-3 minutes. In the third step, the needle was pulled out completely. CT was immediately repeated to assess for pneumothorax. All patients were able to maintain normal respiration during the lung biopsy. All were placed in the supine position after the procedure and underwent chest radiography the next day to rule out a late pneumothorax.

We reviewed the images obtained during CT-guided lung biopsy to evaluate the patient's position and the size, location, and depth of the lesion. In addition, we noted any pneumothorax or chest tube usage. The size of the pneumothorax was defined as the ratio of its maximum depth to the maximum



Fig. 2 The coaxial needle is slowly withdrawn until it is about 5 mm beneath the visceral pleura.

width of the inner chest wall on the same axial section. A ratio less than 10% was small, 10-30% was moderate, and more than 30% was large (severe).

We performed statistical analysis comparing the pneumothorax and no pneumothorax groups using the independent t-test and chi-square test, and performed analysis of reported risk factors (lesion size and depth) and pneumothorax using odds ratios. A *p* value of less than .05 indicated a statistically significant difference.

Pathologic results of the biopsy samples were recorded, as were patient mortality rates after biopsy.

RESULTS

The mean age (\pm standard deviation) of the patients was 66.1 ± 1.2 years (range, 19-91 years). They included 85 men and 61 women.

Pneumothorax occurred in 23 patients (15.8%) and was small in 15, moderate in six, and large in two. Two patients underwent chest-tube insertion because of severe pneumothorax, and their lesions were 4.8 and 5 cm deep. Overall, lesions were 1-5 cm (2.8 ± 0.4 cm) deep and 3.8 ± 0.3 cm in size. Among patients with pneumothorax, all lesions were at least 4 cm deep and smaller than 2 cm; the mean lesion size was 1.6 ± 0.3 cm. Four (17%) of the 23 patients with pneumothorax had emphysema; all of these patients had mild pneumothorax.

Table 1 shows the results of statistical analysis of the reported risk factors for pneumothorax. These data showed that the patients with a lesion size < 2 cm. were 6.2 times as likely to have pneumothorax than those a larger lesion, and patients with lesion

depth > 4 cm. were 4.7 times as likely to have pneumothorax than those with a lesion depth < 4 cm. Small lesions and deep lesions were predictors of pneumothorax. Body position and patient age did not seem to affect the rate of pneumothorax.

Pathologic analysis revealed 109 cases of lung cancer (mostly adenocarcinomas), 11 lung cancers accompanied by infection, 21 cases of chronic inflammation, and three cases of tuberculosis. Five patients died from 2 to 5 months after lung biopsy because of a malignant tumor.

DISCUSSION

Pneumothorax is the most common complication of needle biopsy. The literature reveals rates of pneumothorax vary from 12 to 36%.⁽¹⁻⁵⁾ Numerous groups have suggested possible contributory factors as well as possible means of prevention.⁽³⁻⁵⁾ These factors were divided into several categories and included those related to patient posture, needle size, lesion depth and size, and biopsy technique. In our study, the rate of pneumothorax was related to the size and depth of the lesion (Table 1). Yeow et al⁽⁶⁾ found the highest pneumothorax rate of 33% in patients with lung lesions ≤ 2 cm. Cox et al⁽⁷⁾ used the CT-guided coaxial fine-needle technique, and had a higher pneumothorax rate of 60% for 123 lung lesions ≤ 2 cm compared with a 31% rate in 233 biopsies of larger lesions. Khan et al⁽⁸⁾ demonstrated a pneumothorax rate of 22% for 0-2 cm lung lesions compared with a 13% rate for > 2-4 cm lesions. These results were similar to ours. In our study, all lesions were smaller than 2 cm in patients with pneu-

Table 1. Analysis of Risk Factors for Pneumothorax

Risk factor	Pneumothorax (n = 23)	No pneumothorax (n = 123)	Odds ratios (95% CI)	<i>p</i> value
age	67.4 \pm 2.4	58.7 \pm 1.9	1.2 (0.2, 1.7)	0.33
gender	13 men, 10 women	72 men, 51 women	0.8 (0.7, 2.2)	0.067
Lesion size \pm SD, cm	1.6 \pm 0.3 (0.5-1.9)	4.1 \pm 0.4 (2.4-5.8)	6.2 (1.4, 2.6)	0.029
Lesion depth \pm SD, cm	4.8 \pm 0.4 (4.2-5.0)	1.7 \pm 0.2 (1.0-2.8)	4.7 (1.2, 2.9)	0.017
Body position, no. supine: prone	9: 14*	67: 56*	–	–

Abbreviations: SD: standard deviation; *: The percentage of pneumothorax was 11.8% in the supine position, and 20% in the prone position. Although, pneumothorax are seem more frequently in patients in the prone than the supine position, there was no significant difference between these 2 positions (*p* = 0.4).

mothorax. However, the study of Laurent et al⁽⁹⁾ showed no significant difference between a 15% pneumothorax rate for 67 lung lesions \leq 2 cm compared to a 16% rate for 135 larger lung lesions. Yildirim et al⁽¹⁰⁾ did not find a significant correlation between lesion diameter and pneumothorax rate. In the studies above, the relationship between the pneumothorax rate and lesion size was multivariate. However, Laurent et al⁽⁹⁾ recognized that a needle biopsy for lung lesion $<$ 2 cm is technically more difficult, requiring a longer procedure time that might potentially increase the risk of pneumothorax.

In our study, the depth of the lesion was a predictor of pneumothorax (Table 1). In all patients with pneumothorax, lesions were deeper than 4 cm. Some researchers⁽⁷⁾ found a significantly higher pneumothorax rate for lesions without contact with the pleura than lesions in direct contact with pleura. Several authors have reported that greater lesion depth causes the pneumothorax rate to increase.⁽¹¹⁻¹³⁾ It would be reasonable to hypothesize that a longer needle path may have a greater chance of tearing the pleura and normal lung tissue as patients breathe during the procedure. In contrast, Yeow et al⁽⁶⁾ reported a sevenfold higher risk of pneumothorax for biopsies of subpleural lesions 0.1 to 2 cm below the surface, with a 4.4 times higher risk for deeper lung lesions. This may occur because lesions 0.1 – to 2 cm below the surface are very close to the pleura. Thus, shallow anchoring results in easy needle dislodgement in the pleural cavity, causing air ingress. However, in our technique, the biopsy is done through the tumor and the medial wall surface of the tumor is cut directly, with minimal damage to the pleura. There remains considerable disagreement about the correlation between the pneumothorax rate and the depth of the lesion. Yildirim et al⁽¹⁰⁾ reported that a close relationship between the depth of the lesion and the presence of pneumothorax does not mean that this factor increases the possibility of a pneumothorax.

This biopsy technique also affects the pneumothorax rate. In a review, Moore⁽¹⁴⁾ demonstrated that limiting pleural punctures to only one is crucial to minimize the risk of pneumothorax. The author also describes a method to avoid a second puncture by pulling the tip of the needle back, peripheral to the target. A course correction can be achieved during the coaxial sampling process itself by canting the outer needle. Most cases of needle malposition can

be salvaged in this way to avoid a second puncture. In addition, Moore suggested that corrective manipulations of the needle should be performed by partially withdrawing the needle (but not through the pleura) and by re-advancing it.

Our one puncture, three-step needle-withdrawal method was effective in reducing the pneumothorax rate. The most marked difference between our method and a routine CT-guided method is that we stopped withdrawal in the subpleural and epipleural regions. After obtaining the biopsy samples, we pulled the inner needle back but kept its tip in the sheath of the outer needle. This step is important to stop outside air from entering the pleural cavity through the sheath of the outer needle during needle withdrawal. Atmospheric air can be sucked into the pleural cavity when the needle is pulled out; this air can mimic a pneumothorax during imaging. In the next step, we slowly withdrew the needle, stopping when it was about 5 mm beneath the visceral pleura and holding it there for 2-3 minutes. The purpose of this step is to seal off the tract between the lesion and the parenchyma itself. After this step, we withdrew the needle until it just reached the parietal pleura and kept it there for 2-3 minutes. This step also seals off the tract between the parenchyma and the visceral pleura. Stopping outside air from entering the pleural cavity and sealing off the puncture tract itself reduced the rate of pneumothorax. Our four radiologists followed this procedure, and our pneumothorax rate was 15.8%, which was lower than other reported rates of 35%,⁽¹⁵⁾ 29%,⁽¹⁶⁾ 38%,⁽¹⁷⁾ 26%,⁽¹⁸⁾ 30%,⁽¹⁹⁾ and 28%⁽²⁰⁾ (Table 2). Only Yeow et al reported a lower pneumothorax rate of 12%.⁽⁵⁾ We think this is an observation value, and their data (12%) may be not significantly different than ours (15.8%) statistically. In addition, factors such as different patient characteristics, lesion size, depth, and presence of pleural effusion or emphysema could affect the results. Despite some limitations, such as the limited case number and lack of a control group, we believe our technique has clinical impact.

In conclusion, our modified CT-guided lung biopsy method, the three-step needle withdrawal technique, appears effective with a relatively low pneumothorax rate. According to analysis with odds ratios, a lesion deeper than 4 cm and a lesion smaller than 2 cm were predictors of pneumothorax in our study.

Table 2. Relative Parameters for the Pneumothorax Rate in Published Studies

Authors	Patient number	Patient age	Pneumothorax rate (%)	Lesion depth (cm)	Lesion size (cm)	Needle gauge guidance	cutting
Moore EH ⁽⁷⁾	160	59.7 ± 0.3	35	3.6 ± 0.5	1.5 ± 0.4	17	18
Anderson CL ⁽⁸⁾	214	65.4 ± 0.5	29	4.3 ± 0.2	1.9 ± 0.3	18	19
Geraghty PR ⁽⁹⁾	184	63.2 ± 0.5	38	3.9 ± 0.4	1.9 ± 0.5	17	18
Geraghty PR ⁽⁹⁾	132	59.1 ± 0.6	23	3.8 ± 0.7	2.0 ± 0.3	18	19
Williams SW ⁽¹⁰⁾	221	58.1 ± 0.4	26	4.2 ± 0.6	2.2 ± 0.1	17	18
Poe RH ⁽¹¹⁾	105	57.1 ± 0.2	30	4.4 ± 0.5	2.1 ± 0.6	17	18
Engeler CE ⁽¹²⁾	110	60.9 ± 0.8	28	3.7 ± 0.7	1.8 ± 0.3	18	19
Our research	146	66.1 ± 1.2	15.8	4.8 ± 0.4	1.6 ± 0.3	17	18

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降低電腦斷層掃描指引之同軸針肺部穿刺後氣胸發生之修正方法

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背景：電腦斷層掃描指引之同軸針肺部穿刺，對於肺部損害或腫瘤而言，是可信賴的診斷方法。而氣胸是在進行同軸針肺部穿刺後，最常發生的併發症。本研究的目的是報告一個「三步驟拔針法」的技術，此技術強調可降低肺部穿刺後氣胸的發生率。

方法：146 位患有肺部腫瘤的病患 (85 名男性, 61 名女性, 平均年齡為 66.1 歲), 至本科接受電腦斷層掃描指引之同軸針肺部穿刺檢查。我們使用 17 號的指引針及 18 號的穿刺針以進行穿刺。此外, 我們使用「三步驟拔針法」以移出穿刺針。影像判讀方面, 我們記錄了病患的姿勢、腫瘤的大小、位置及深度。病患是否發生氣胸或是插胸管, 也必須加以記錄。

結果：有 23 名病患 (15.8%) 在穿刺後發生氣胸現象, 其中有兩位必須插胸管。所有發生氣胸的病患中, 他們的腫瘤深度皆深於 4 公分, 而腫瘤大小皆小於 2 公分。

結論：本科病患在進行電腦斷層掃描指引之同軸針肺部穿刺之後, 氣胸之發生率為 15.8%, 顯示「三步驟拔針法」有相對較低之氣胸發生率。而在本研究中, 腫瘤深度深於 4 公分, 腫瘤大小小於 2 公分是肺部穿刺後發生氣胸的危險因子。
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關鍵詞：穿刺併發症, 電腦斷層, 肺部穿刺, 氣胸, 技術

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