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FULL PAPER

Efficacy of an opposite position aspiration on resolution of pneumothorax following CT-guided lung biopsy

¹L-C ZENG, MS, ²Y DU, MD, ²H-F YANG, MD, ¹M-G XIE, BA, ¹H-Q LIAO, BA, ¹Y-D ZHANG, MS, ¹L LI, MD, ³Q WANG, BA, ¹L HU, BA and ²X-X XU, MD

¹Department of Radiology, Teaching Hospital of Chengdu University of Traditional Chinese Medicine, Chengdu, Sichuan, China

²Department of Interventional Pain Management, Affiliated Hospital of North Sichuan Medical College, Sichuan Key Laboratory of Medical Imaging, Nanchong, Sichuan, China

³Department of Ultrasound, Teaching Hospital of Chengdu University of Traditional Chinese Medicine, Chengdu, Sichuan, China

Address correspondence to: Mrs Xiao-xue Xu

E-mail: nclittlesnow@163.com

Objective: To evaluate the efficacy of aspiration in an opposite position to deal with pneumothorax after CT-guided lung biopsy.

Methods: A retrospective study was developed involving 210 patients with pneumothorax who had undergone CT-guided percutaneous core biopsies from January 2012 to March 2014 for various pulmonary lesions. Asymptomatic patients with minimal pneumothorax were treated conservatively. Simple manual aspiration was performed for symptomatic patients with minimal pneumothorax and for all patients with moderate to large pneumothorax. An opposite position aspiration was performed when simple manual aspiration failed. The efficacy of simple manual aspiration and the opposite position aspiration was observed.

Results: Among 210 patients with pneumothorax, 128 (61.0%) asymptomatic patients with minimal pneumothorax were treated conservatively. The remaining 82 were treated with attempted simple manual aspiration. Out of these 82 patients, simple manual aspiration was successful in 58 (70.7%, 58/82) cases. The complete and partial regression rates were 17.2% (10/58) and 82.8% (48/58),

respectively. In the other 24 patients (29.3%, 24/82), simple aspiration technique was ineffective. An opposite position (from prone to supine or *vice versa*) was applied, and a new biopsy puncture site was chosen for reaspiration. This procedure was successful in 22 patients but not in 2 patients who had to have a chest tube insertion. The complete and partial regression rates were 25.0% (6/24) and 66.7% (16/24), respectively. Applying the new method, the total effective rate of aspiration improved significantly from 70.7% (58/82) to 97.6% (80/82).

Conclusion: The opposite position aspiration can be safe, effective and minimally invasive treatment for CT-guided lung biopsy-induced pneumothorax thus reducing the use of chest tube significantly.

Advances in knowledge: (1) Opposite position aspiration can elevate the success rate of aspiration significantly (from 70.7% to 97.6% in our study); (2) this procedure is a safe, effective and minimally invasive treatment for pneumothorax caused by biopsy; and (3) opposite position aspiration is a useful technique to reduce the use of chest tube, which has clinical significance.

CT-guided transthoracic needle biopsy is an established and safe technique for the diagnosis of lung lesions. Pneumothorax is the most frequent complication of this technique.¹⁻⁴ Chest tube placement is associated with higher levels of pain and anxiety, and opioid pre-medication and local anaesthesia is required.⁵ The infection risk and in-patient stay increased significantly. Numerous modifications to the technique have been evaluated in an attempt to manage biopsy-induced pneumothorax and to reduce the number of cases that require chest tube placement. The purpose of this study was to evaluate the efficacy of changing the posture and/or puncture site in the treatment of pneumothorax following CT-guided lung biopsies.

METHODS AND MATERIALS

Patients

Between January 2012 and March 2014, 1560 consecutive percutaneous core biopsies of the lung were performed on 1450 patients, and pneumothorax occurred in 210 cases. 82 patients with pneumothorax, who have aspiration, were included in this retrospective study. The average age was 51.5 ± 10.2 years (age range, 25–80 years). Comparisons between the successful simple aspiration and opposite position aspiration are summarized in Table 1. Those who did not undergo an attempt at simple aspiration were excluded from our study. The study was approved by the medical ethics committee.

Table 1. Comparison of simple aspiration and opposite position aspiration

Parameter	Simple aspiration	Opposite position aspiration	<i>p</i> -value
Mean age (years)	50.2 ± 11.3	53.2 ± 8.5	0.265
Gender (male/female)	34/24	13/9	0.970
Supine/prone	32/26	10/12	0.437
Lesion size (mm)	47.5 ± 13.2	36.3 ± 10.2	0.025 ^a
Lesion depth (mm)	45.3 ± 12.5	60.3 ± 9.5	0.028 ^a
Number of punctures	1.3 ± 0.3	1.9 ± 0.7	0.008 ^a
Number of biopsies	1.7 ± 0.5	2.3 ± 0.5	0.019 ^a
Aspirated air (ml)	328.5 ± 158.3	537.3 ± 354.2	0.018 ^a

^aThere were significant differences in two groups ($p < 0.05$).

Procedures

Biopsy protocol

Patients were placed on the table in prone or supine position. Pre-interventional lesion location was documented with CT (Xvision GX; Toshiba, Tochigi, Japan) in axial sections and skin marker placed at the entry site. On the preparatory images, the distance and angle from the needle access site to the lesion were measured. Local anaesthesia was achieved with 1% lidocaine hydrochloride. Careful gradual insertion of a coaxial needle guide (19G, C2016B, Bard) through the patient's chest wall was performed. A single pleural puncture was made in almost all needle biopsies. The correct needle position was documented after which the innerpuncture stylet was removed from the needle guide to allow coaxial insertion of automated cutting needle (MN2016, Bard). Subsequently, the automated biopsy system was fired. Core specimens were placed in 10% formalin for pathological examination. Immediately after biopsy, CT of the lung lesion with 5-mm slices was performed to evaluate the presence of possible complications.

Treatment of pneumothorax

Minor pneumothorax was defined as the distance (D) between parietal and visceral pleura was <1 cm, moderate pneumothorax when it was 1–2 cm and large pneumothorax when >2 cm.² The management of pneumothorax was decided in terms of follow-up CT. Asymptomatic patients with a minimal ($D \leq 1$ cm) pneumothorax were treated conservatively. Simple manual aspiration was performed immediately in symptomatic patients with minimal pneumothorax and in all patients with moderate ($D > 1$ cm) and large pneumothorax ($D > 2$ cm). In these patients, the needle from the lesion was retracted back into the pleural space. A confirmatory CT scan was performed to localize the presence of tip in the pleural space. Then, the needle stylet was removed, and a three-way stopcock (ST 02; Hangzhou Jinlin Medical Appliances Co., Ltd, Zhejiang, China) was connected with the puncture needle. The air was aspirated and expelled by a syringe from the pneumothorax. When resistance was encountered, CT was performed to confirm whether a complete or almost complete reexpansion of the lung had been achieved.

Cases with failed aspiration were then turned to the opposite side (e.g. turned to supine position in a posterior needle approach and to prone position in an anterior needle approach), and a new

puncture site, away from the primary biopsy puncture site was chosen for reaspiration. CT was performed to confirm the adequate position of the needle-tip and reaspiration was conducted. Oxygen was administered during and after the procedures. After the aspiration of pneumothoraces, the patients were then placed in such a position that would allow the primary biopsy puncture site to be underneath the body. Speaking was prohibited, and deep breathing was limited. If the pneumothorax did not improve and the air leak persisted a 7-Fr chest tube was inserted (BT-PD1-0730-W; Taipei, Taiwan). All procedures were performed by four interventional radiologists (experience of 2–8 years).

Data analysis

Patients were followed up with CT scan at 1 h after the procedure to check for pneumothorax. The maximum diameter of the pneumothorax was measured and compared with the pre-treatment diameter. The resolution of symptoms and disappearance of pneumothorax were considered to be complete regression. The relief of symptoms along with a reduction in the diameter of the pneumothorax by more than one half was considered partial regression. Treatment was considered to have failed when the pneumothorax recurred to more than one-half the diameter before the treatment or the symptoms persisted.

Student's t test, χ^2 test and Fisher's exact test were used to compare differences in response between the two groups. The level of statistical significance was set at $p < 0.05$. Statistical analysis was performed using statistical software (SPSS® v. 16.0; SPSS Inc., Chicago, IL).

RESULTS

Among 210 patients with pneumothorax, 128 (61.0%, 128/210) asymptomatic patients with minimal pneumothorax were treated conservatively. The remaining 82 patients were treated with simple manual aspiration. Out of those 82 patients, simple manual aspiration was successful in 58 (70.7%, 58/82) patients. The complete and partial regression rates were 17.2% (10/58) and 82.8% (48/58), respectively.

In the other 24 patients (29.3%, 24/82), simple aspiration was ineffective. An opposite position (from prone to supine or *vice versa*) was applied, and a new biopsy puncture site was chosen for reaspiration (Figure 1). This procedure was successful in 22 of 24 patients with 2 patients undergoing a chest tube insertion.

Figure 1. A 56-year-old female with a right upper lobe mass. (a) A 19-G puncture needle was inserted into the lesion for biopsy. (b) Complication of pneumothorax was detected after biopsy and the subsequent simple aspiration was ineffective. (c) The patient was turned to the opposite side (biopsy puncture site down) for reaspiration. (d) A new puncture site was chosen, and the reaspiration was conducted. (e) The almost complete re-expansion of the lung had been achieved.

The complete and partial regression rates were 25.0% (6/24) and 66.7% (16/24), respectively. By applying the opposite position aspiration, total effective rate of aspiration elevated significantly from 70.7% (58/82) to 97.6% (80/82). Results of simple aspiration and combination of the opposite position aspiration are listed in [Table 2](#).

The chest tube placement was performed only in 2 cases from the 210 patients with pneumothorax (0.95%, 2/210). One case had a large pneumothorax (approximately 60–70%). The patient suffered from severe dyspnoea and hypoxaemia. As the reaspiration in this case was ineffective, a chest tube had to be inserted. Another patient had a persistent pneumothorax. The reaspiration was effective for a short period only. Follow-up CT was performed 5 min after the reaspiration revealed a recurrence of pneumothorax. Thus, a chest tube was inserted in this patient. We observed no serious side effects such as bleeding or lung oedema after the procedure. The study flow diagram is provided in [Figure 2](#).

DISCUSSION

CT-guided lung biopsy is commonly used to make a histological diagnosis for pulmonary lesions. Pneumothorax is the most frequent complication of CT-guided lung biopsy, ranging from 8.2% to 54.3% according to reports.^{6–9} Several risk factors are considered to be related to the incidence of pneumothorax, including needle size, lesion size, lesion depth, the presence of emphysema etc.^{10–13} and the rate of chest tube placement varies from 2% to 18%.^{2,14–16} Such interventions may lead to hospital admission for observation and follow-up chest radiography.

This study enrolled 210 patients with pneumothorax. 82 patients (39.0%, 82/210) were treated with simple manual aspiration, which was successful in 58 patients (70.7%, 58/82) similar to several other studies reported in the international literature that had a range of 57–75%.^{17,18} In the other 24 patients, simple aspiration was ineffective. Changing of the posture and puncture site was executed after the failed first attempt, and this reaspiration

Table 2. Results of simple aspiration and combination of the two procedures

Result	Simple aspiration	Combination of simple aspiration and opposite position aspiration	<i>p</i> -value
Complete regression	10/82 (12.2%)	16/82 (19.5%)	0.200
Partial regression	48/82 (58.5%)	64/82 (78.0%)	0.007
Failed	24/82 (29.3%)	2/82 (2.4%)	0.000
Overall success rate	58/82 (70.7%)	80/82 (97.6%)	0.000

was successful in 22 patients who would have otherwise required a chest tube placement.

In our study, the patients with a biopsy-induced pneumothorax for reaspiration were positioned with the biopsy puncture site changed from above to below (puncture site down). Only two patients from this group needed chest tube insertion. The overall success rate of aspiration elevated to 97.6% (80/82), which was significantly higher than other reports.^{17,19–21} The chest tube was placed in only 0.95 % (2/210) of all pneumothorax patients, which was significantly lower than international reports that ranged from 2% to 18%.

Air cannot enter into the pleural space because the chest wall and visceral pleura are physical barriers to entry. There are three mechanisms that allow air to enter the pleural space:²² (a) communication with the outside atmosphere, (b) visceral pleural rupture and (c) the presence of gas-producing organisms. The first two factors contribute to biopsy-induced pneumothorax. An unskilled approach to the procedure may cause the pleural space to communicate with the outside atmosphere. Air may enter the pleural space to induce the formation of pneumothorax most of which are minor to moderate in volume. Visceral pleural rupture is the most important contributing factor in biopsy-induced pneumothorax, which could be moderate to large in volume. Yamagami et al¹⁷ reported that simple aspiration is a safe and effective method in the treatment of biopsy-induced pneumothorax and is a simpler approach than chest tube placement. But simple manual aspiration may be insufficient if the

parenchymal tear is large enough, and it theoretically carries a high risk of short-term recurrence because (a) it does not promote pleural symphysis and (b) the aspiration around the visceral pleural rupture may increase the alveolar-to-pleural pressure gradient in the region surrounding the leak.²³

Moore et al²⁴ reported that puncture-site-down post-biopsy positioning could reduce the proportion of patients requiring chest tube placement after lung biopsy. The present study showed an encouraging result for biopsy-induced pneumothorax. There were several factors that might have contributed to the high success rate in our study. Firstly, all of the 210 patients with pneumothorax were kept in a position with puncture site down after the procedures. Secondly, changing the patient's position with puncture site down may cause the edges of pleural tears to overlap, thereby providing a physical barrier to further air leakage after the development of pneumothorax.^{25,26} Thirdly, puncture-site-down position was beneficial for the visceral and parietal pleura symphysis. Finally and importantly, a different puncture site away from the biopsy puncture site was chosen for reaspiration that did not increase the alveolar-to-pleural pressure gradient in the region surrounding the leak. We believe that resolution or substantial reduction of pneumothorax may be achieved through such a combination of techniques.

The primary limitation of this study was that it was not a prospective, randomized controlled trial. Clinical application and interpretation of this study should take this limitation into

Figure 2. Study flow diagram.

account. However, this study does suggest that the use of opposite position aspiration elevates the total effective rate for lung biopsy-induced pneumothorax. Second, the number of our cases was limited; larger patient population trials may be needed to answer the treatment question definitively.

In conclusion, when pneumothorax is revealed after CT-guided lung biopsy, the size of pneumothorax is small and the patient is asymptomatic, observation alone is adequate. Immediate simple percutaneous aspiration is recommended for any symptomatic

patient or moderate to large pneumothoraces. If the immediate simple aspiration fails, puncture site down and change of puncture site should be performed for reaspiration. The present study result clearly demonstrates the safety and efficacy of the methods in the treatment of biopsy-induced pneumothorax and significant reduction of chest tube placement.

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