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Computed tomography-guided lung biopsy with the patient in lateral decubitus position and the biopsy side down: Effect on pneumothorax rate and clinical significance

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ABSTRACT

Purpose: The purpose of our study is to assess the effect of patient positioning (prone or supine *versus* lateral decubitus position) upon the rate of pneumothorax, during computed tomography (CT)–guided trans-thoracic needle biopsy of pulmonary lesions.

Material and Methods: We retrospectively reviewed data from CT-guided lung biopsies (249 patients) performed in our department during the last four years. 186 biopsies were performed with the patient on prone or supine position (Group A) and 63 were performed with the patient placed on lateral decubitus position with the biopsy-side down (Group B). Statistical analysis was performed between the two groups for pneumothorax, including patient demographic characteristics, lesion characteristics, and biopsy technique. We also compared the results of biopsies performed by the same interventional radiologist between groups.

Results: An increased number of pneumothorax was noted in Group A [29 (15.6%)] compared to Group B [1 (1.6%) *p*=0.003]. There was also an increased number of drainage catheter insertions in Group A compared to Group B [11 (5.9%) *versus* 0 (0%), respectively, *p*=0.048]. Higher rates of pneumothorax (14.7%) and pneumothorax requiring treatment (6.7%) were also noticed in biopsies of group A performed by the same interventional radiologist who performed biopsies in group B, compared to biopsies in contralateral position, and these differences were statistically significant (*p*=0.007 and *p*=0.037). Lesion size and emphysema along the needle track were independent risk factors for pneumothorax

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in group A. Emphysema along the needle track was an independent predictor for insertion of a drainage catheter in Group A. No independent predictor was identified for pneumothorax or insertion of a drainage catheter in Group B.
Conclusions: Performing percutaneous CT-guided trans-thoracic lung biopsy with the patient placed on lateral decubitus position with the biopsy-side down reduces the rate of pneumothorax and pneumothorax necessitating a drainage catheter. Application of this technique attenuates the influence of traditional risk factors for pneumothorax.

KEY WORDS
pneumothorax; lung; biopsy; position; lateral

1. Introduction

Percutaneous Computed Tomography (CT) guided lung biopsy [Trans-thoracic needle biopsy TTNB)] is a well established technique for the diagnostic evaluation of pulmonary nodules or masses. Its diagnostic accuracy rates range between 77% and 99% with a pooled mean success rate of 89% [1, 2]. The complications of this technique include pneumothorax, pulmonary haemorrhage with or without haemoptysis, haemothorax, tumour seeding along the needle tract, chest infection, empyema and cardiac tamponade [1, 3]. The most commonly reported complication of TTNB is pneumothorax [1-6]. Reported rates of pneumothorax vary from 0% to 53%, depending on the technique and the instrumentation used [1-7]. Clinically significant (requiring drainage) pneumothorax rates range from 3.3% to 15% [1-7].

Factors governing pneumothorax rates include patient population, procedural technique, operator experience, and methods of detection [8]. Predisposing factors include bullae, emphysema, ventilatory obstruction, deep parenchymal or small-sized lesions, lesion abutting fissures, acute angle between the needle and the pleura, greater number of needle passes and more than one crosses of the pleural surface [8-10]. Although many investigators have evaluated modifications of the technique in order to reduce pneumothorax rate, the literature still remains controversial. In addition, some authors have studied the effect of post-biopsy positioning on the incidence of pneumothorax [11-22].

The purpose of this study is to assess the effect of patient positioning (prone or supine *versus* lateral decubitus position) upon the rate of pneumothorax, during CT-guided TTNB of pulmonary lesions.

2. Material and methods

Patients were informed about the benefits of the technique and the related complication and written informed consent was obtained. This study was approved by the review board of our institution. The principles of national legislation and the Declaration of Helsinki were followed.

We retrospectively studied data from 384 CT-guided TTNB consecutively performed in our department during the last 4 years. Review was performed by DF (Interventional Radiologist with 7 years of experience). The reviewer at the time of review was blind to the results of other studies. We excluded 135 cases in which the target–lesion was in contact to the pleura and no lung parenchyma was punctured. We evaluated data from the remaining 249 patients, aged 46-90 (mean age 69.05 years) who underwent percutaneous TTNB during the last 4 years due to the presence of a single lesion completely surrounded by lung parenchyma and without any contact to the pleura. There were 138 male patients (55.4%, mean age 69.4 years) and 111 female (44.6%, mean age 68.6 years). Each patient underwent a single biopsy.

Patients were divided in two groups according to their position during the biopsy. 186 biopsies were performed with the patient on prone or supine position (Group A). Group A was composed of 102 male (54.8%) and 84 female patients (45.2%). Mean patient age was 68.8 years. Biopsies in Group A were performed by three interventional radiologists; 75 biopsies in group A were performed by the same interventional radiologist who performed the biopsies in group B.

Sixty-three biopsies were performed with the patient placed on lateral position with the biopsy-side down (Group B). Group B was composed of 36 male (57.1%) and 27 female

Table 1. Patient's demographics

	Biopsies	Age	Male	Female
Group A	186	68.8 ± 8.5	102 (54.8%)	84 (45.2%)
Group B	63	69.7 ± 8.4	36 (57.1%)	27 (42.9%)
Total	249	69.05 ± 8.5	138 (55.4%)	111 (44.6%)

Table 2. Lesion diameter, skin-lesion distance and presence of emphysema

	Lesion diameter	Skin – lesion distance	Emphysema
Group A N=186	32.9 ± 12.2	44.4 ± 16.6	60 (32.3% within group A)
Group B N=63	30.8 ± 10.9	48.1 ± 14.1	16 (25.4% within group B)
Total N=249	32.4 ± 11.9	45.3 ± 16.0	76 (30.5% of total)

patients (42.9%). Mean patient age was 69.7 years. All biopsies in Group B were performed by the same interventional radiologist during the last 18 months. Patients' demographics are summarised in **Table 1.** Statistical analysis was performed comparing results between the two groups, as well as between group B and biopsies of group A performed by the same interventional radiologist.

Mean lesion diameter was 32.4 ± 11.9. In all cases lung parenchyma was punctured for the biopsy needle to reach the lesion. Mean skin-lesion distance was 45.3 ± 16.0. Mean skin-lesion distance in Group A was 44.4 ± 16.6 *versus* 48.1 ± 14.1 in Group B. Emphysema was noticed in 76 patients (30.5%), 60 cases (32.3%) in Group A and 16 cases (25.4%) in Group B. These differences were not statistically significant (p=0.307). Lesion characteristics and presence of emphysema are summarised in **Table 2.**

A pre-biopsy chest CT scan was available for biopsy planning in each case. All biopsies included in the present study were performed with direct puncture; neither a coaxial trocar for multiple sampling nor any post biopsy sealing devices were used. Prothrombin time (PT), activated partial thromboplastin time (APTT), and platelet count were evaluated prior to the biopsy session; a platelet count <100,000, APTT ratio or PT ratio >1.4 were considered contraindications. In cases where coagulation medication withdrawal should have been applied, the CIRSE-SIR consensus guidelines were followed [23, 24]. Under local anaesthesia, local sterility and CT guidance, lung biopsy was performed using an 18 Gauge semi-automatic biopsy needle (**Fig. 1**). Oxygen saturation, blood pressure and cardiac rate were recorded during the intervention and periodically (every 30 minutes) in the following 4 hours. CT scan was performed immediately after needle withdrawal in order to identify complications. All patients underwent a chest radiograph 4 hours after the procedure and exited the hospital upon absence of clinical or imaging findings suggesting pneumothorax.

Patients from both groups were confined to bed for a minimum of 4 to 6 hours. In the first 3 hours, all patients from both groups lay with the biopsy side down. In case of chest pain, dyspnoea, or hypoxia a chest radiograph was obtained immediately. Small, not clinically significant pneumothoraces were managed conservatively, with close monitoring of the patient and chest radiograph follow up. Pneumothoraces that produced dyspnoea, hypoxia, or occupied >30% of the hemithorax, were treated with the insertion of a drainage catheter under CT-guidance. Detailed description of the catheter insertion technique is beyond the scope of this study.

Statistical analysis

Patient demographic characteristics are expressed as the mean ± standard deviation. Statistical analysis was performed comparing pneumothorax rates between the two

Table 3. Pneumothorax rates between the two Groups

Results	Pneumothorax	Pneumothorax requiring treatment
Group A N=186	29 (15.6% within group A)	11 (5.9% in group A)
Group B N=63	1 (1.6% within group B)	0
P value (comparison Group A- Group B)	*p*=0.003	*p*=0.048
Biopsies in Group A performed by the same physician with Group B N=75	11 (14.7%)	5 (6.7%)
P value (comparison for the same physician)	*p*=0.007	*p*=0.037
Total N=249	30 (12.0% within total)	11 (4.4%)

Table 4. Emphysema and pneumothorax in Group A (patient in supine or prone position during CT-guided biopsy)

Group A N=186	Pneumothorax N=29	No Pneumothorax N= 157	Pneumothorax requiring treatment N=11
Emphysema N=60	15 (25.0% with emphysema)	45 (75.0% with emphysema)	7 (11.7% with emphysema)
Without Emphysema N=126	14 (11.1% without emphysema)	112 (88.9% without emphysema)	4 (3.2% without emphysema)
P value	*p*=0.015		*p*=0.022

groups (Chi-Square Tests). We also compared the results of biopsies performed by the same interventional radiologist between groups. The rate of pneumothorax requiring intervention was also assessed. Binary logistic regression analysis was performed for both groups. Pneumothorax and pneumothorax requiring drainage were the dependent variables. Independent variables were age, sex, lesion size, lesion-skin distance. Furthermore the influences of lesion size and lesion-skin distance upon pneumothorax rate were evaluated with student's T-Test. P values less than 0.05 were considered to indicate a statistically significant difference. IBM SPSS Statistics (version 21) was used.

Results

Both intra-procedural and post-procedural pneumothoraces were included in the results. In Group A there were 29 pneumothoraces (15.6%) *versus* 1 pneumothorax (1.6%) in Group B. This difference was statistically significant (*p*=0.003). Pneumothorax requiring treatment was recorded in 11 cases (5.9%) in Group A, *versus* 0 (0%) in Group B. This difference was statistically significant too (*p*=0.048). Higher rates of pneumothorax (14.7%) and pneumothorax requiring treatment (6.7%) were also noticed in biopsies of group A performed by the same interventional radiologist who performed biopsies in group B, compared to biopsies in contralateral position, and these differences were statistically significant (*p*=0.007 and *p*=0.037). Pneumothorax rates in the two groups are summarised in **Table 3.**

Emphysema was an independent risk factor for pneumothorax in Group A. Pneumothorax occurred in 15 of 60 patients with emphysema (25.0%) in Group A *versus* 14 of 126 patients without emphysema (11.1%). This finding was statistically significant (*p*=0.015). Emphysema was also an independent risk factor for pneumothorax necessitating a drainage catheter insertion in Group A. Pneumothorax drainage was performed in 7

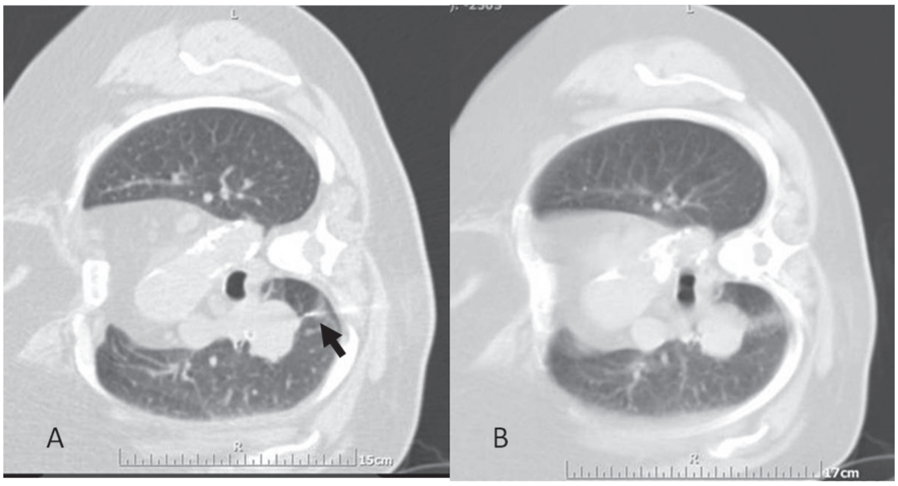

Fig. 1.
A-B: Computed Tomography axial scans (A–B) during trans-thoracic lung biopsy with the patient in lateral decubitus position.
(A): Tip of the needle is just at the edge of the lesion (arrow).
(B): POST trans-thoracic lung biopsy with minor haemorrhage surrounding the lesion but no evidence of pneumothorax

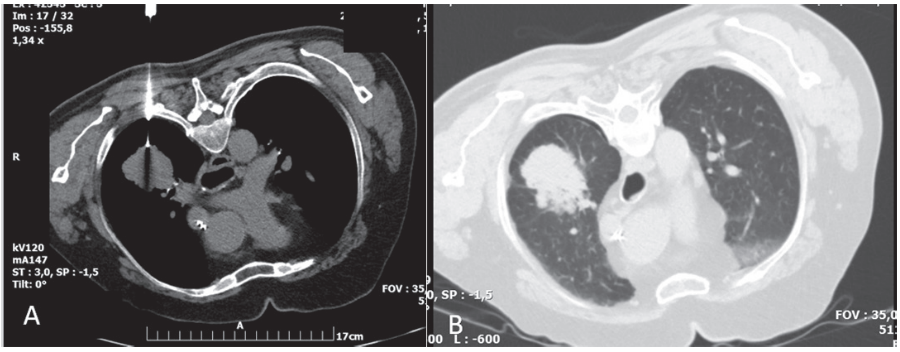

Fig. 2.
Computed Tomography axial scans during trans-thoracic lung biopsy with the patient in prone position.
(A): Tip of the needle is just at the edge of the lesion
(B): POST trans-thoracic lung biopsy image showing a small pneumothorax

of 60 (11.7%) patients with emphysema and in 4 of 126 (3.2%) patients without emphysema (p=0.022) (**Table 4**).

Lesion size influenced pneumothorax rate in Group A. Mean lesion diameter in cases complicated with pneumothorax was 28.4 ± 10.2 *versus* 33.8 ± 12.4 in cases without pneumothorax (p=0.016). Mean lesion diameter in Group A was 32.9 ± 12.2.

There was only 1 pneumothorax (1.8%) in Group B. There was no need for drainage catheter insertion in Group B. No independent risk factor was identified in Group B for pneumothorax or pneumothorax requiring intervention.

Discussion

Literature references concerning patient positioning during and after the procedure are controversial (11-13, 16-19). There are authors suggesting that lung biopsy with the patient in an ipsilateral dependent position is a feasible, effective and safe technique, useful in reducing pneumothorax rate [16, 17]. Additionally, when patient is immediately placed with the puncture side down at the end of the process seems to reduce the rate of overall pneumothorax and pneumothorax necessitating a drainage catheter [11-15]. On the other hand many investigators reported no correlation between patients' position after biopsy and pneumothorax rates as well as no effect of puncture site down post-biopsy either on the incidence of post-biopsy pneumothorax, or pneumothorax requiring tube placement [16, 17]. British Thoracic Society 2003 guidelines stated that post-biopsy positioning had not been found to decrease the rate of pneumothorax [3].

The results of this study indicate that there was a statistically significant reduction in pneumothorax rate and pneumothorax necessitating drainage when patients were placed in lateral decubitus position with the puncture side down during the biopsy. Our results come in agreement to the conclusions of Rozenbit and Kinoshita who reported that this technique was feasible, effective, safe and useful in reducing pneumothorax rate [18, 19]. Statistical analysis between the two groups for pneumothorax rate indicated that emphysema and lesion size were independent risk factors for pneumothorax and pneumothorax requiring intervention occurrence in Group A (patients in supine or prone position during CT-guided biopsy).

The literature concerning the potential pathophysiologic basis of pneumothorax rate reduction in dependent position is controversial. Potential explanations include the reduction of alveolar size along the needle route, the reduction of pressure difference among alveoli and pleura at the puncture point and the dependent accumulation of haemorrhagic fluid along the needle tract [11, 15]. Furthermore the weight of the lung maintains a compact contact among visceral and parietal pleura and results in a minimisation of air leakage [15]. Based on the aforementioned potential pathophysiologic explanations, various modifications of lung biopsy technique have been performed aiming in pneumothorax rate reduction including rapid needle out-rollover time or blood patching [7, 15, 25-27].

This study has several limitations: There was a difference in the patient number among the two Groups; 186 in Group A *versus* 63 in Group B. The inclusion period was 48 months for group A, *versus* 18 months for Group B. All biopsies in Group B were performed by the same Interventional Radiologist, whereas biopsies in Group A were performed by three different Interventional Radiologists (one of them being the IR performing biopsies in Group B). However even when we compared biopsies in Group A and B performed by the same Interventional Radiologist higher rates of pneumothorax (14.7%) and pneumothorax requiring treatment (6.7%) were also noticed when the patient was not in the lateral decubitus position, and these differences were statistically significant (p=0.007 and p=0.037).The number of pneumothoraces in group B was too small to evaluate potential significant risk factors. However, this could be more related to the Group's low complication rate than its overall number of patients. We have excluded 135 patients who underwent biopsy of subpleural lesion in order to avoid selection bias favouring lateral decubitus position since this is a perfect opportunity for this approach but the lack of passing through lung parenchyma diminishes the pneumothorax chance. Finally, the study was retrospective and there was no randomisation process in patient selection.

In conclusion, CT guided percutaneous lung biopsies with the patient in lateral decubitus position with the biopsy side down seem to result in statistically significant reduced rates of pneumothorax and pneumothorax requiring treatment when compared to biopsies with the patient in prone or supine position. Despite these encouraging results, more (and preferably randomised) studies with larger patient groups are necessary in order to confirm the exact effect of placing the puncture site down on pneumothorax rate and to evaluate the potential reduction of the impact of known risk factors, such as emphysema and lesion size. **R**

Conflict of interest:
The authors declared no conflicts of interest.

Research ethics and compliance:
All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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