Short versus long trans-pulmonary needle pathway for CT-guided percutaneous core needle biopsy of small sub-pleural pulmonary nodules

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ABSTRACT

Introduction: Short lesion-pleural distance allows little space for manipulation of biopsy needle with high risk of needle dislodgement into pleural space causing air leak and subsequently pneumothorax. This study compared short trans-pulmonary biopsy approach with long trans-pulmonary approach for small sub-pleural pulmonary nodule to determine approach with lesser complication and better diagnostic yield. **Methods:** A total of 65 patients who were undergoing CT guided biopsy for small (≤20 mm) sub-pleural (≤10 mm) pulmonary nodules were divided into two groups depending upon biopsy approach, i.e., long trans-pulmonary biopsy approach (group A, n=34) and short trans-pulmonary biopsy approach (group B, n=31). Diagnostic accuracy and complication rate between the groups were compared. **Results:** No significant difference was found between two groups in case of diagnostic accuracy (Group A vs Group B: 91.2% vs 87.1%; p=0.59). Pneumothorax rate was higher in group B (29.0%) compared to group A (14.7%), however, difference was not statistically significant (p=0.16). Among risk factors for pneumothorax, smaller lesion size (5-10 mm), short lesion-pleural distance (≤ 5 mm) and number of pleural passes (>1) was associated with significantly higher pneumothorax rate in group B compared to group A (71.4 vs 40% p=0.02; 85.7% vs 16.6% p=0.01; 100% vs 57.1% p=0.01 respectively). **Conclusions:** Smaller sub-pleural pulmonary nodules render high risk of pneumothorax with the use of short trans-pulmonary pathway. If the nodule is very close to pleura and relatively smaller where one could not ensure access with single puncture, long trans-pulmonary pathway serves as safer option to avoid pneumothorax.

Keywords: CT-guided biopsy, pneumothorax, pulmonary nodule, sub-pleural.

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INTRODUCTION

CT-guided core needle biopsy (CNB) has high diagnostic accuracy for pulmonary lesions with acceptable complications.[1-3] Pneumothorax has been reported as a most common complication of the procedure with an incidence rate ranging from 4.0% to 62.0%.[4,5] Moreover, proximity of lesion to pleura makes it more prone to complicate pneumothorax.[2,6] Furthermore, when such sub-pleural lesions are smaller in size many passes might be necessary to reach the appropriate section to collect optimal sample which in turn further increases the risk of pneumothorax.[7] Therefore, biopsy of small sub-pleural lesions is very challenging. Two different approaches to access these lesions have been used in clinical practice, i) a direct puncture and traversing a short distance of aerated lung or ii) an indirect puncture involving a long trans-pulmonary needle pathway, with contradictory results in relation to complications rate have been reported in literature raising a clinical dilemma to which approach should be followed in these patients.[8-10]

In our clinical experience, we found short trans-pulmonary pathway easier to access the lesion. However, in this approach distance between needle tip and pleura is less and thus, patient's respiratory movement, multiple passes to access the lesion or manipulation of needle can easily result in pneumothorax. On the other hand, a long trans-pulmonary needle pathway provides more space to anchor the needle and manipulate needle to gain access to the desired section of lesion to be biopsied. Besides, long trans-pulmonary route offers more passage options than the short trans-pulmonary route. Therefore, in this study we aimed to compare two different biopsy approaches to small sub-pleural nodule in quest to find out an approach with less complications and better diagnostic yield.

METHODS

The current study was conducted in accordance with the 1964 Declaration of Helsinki and was approved by the Institutional Review Committee of Birat Medical College Teaching Hospital (Affiliated to Kathmandu University), Ref.No.IRC-PA-407/2024. Written informed consent was obtained from all the patients. The flow diagram of research methodology is shown in Figure 1.

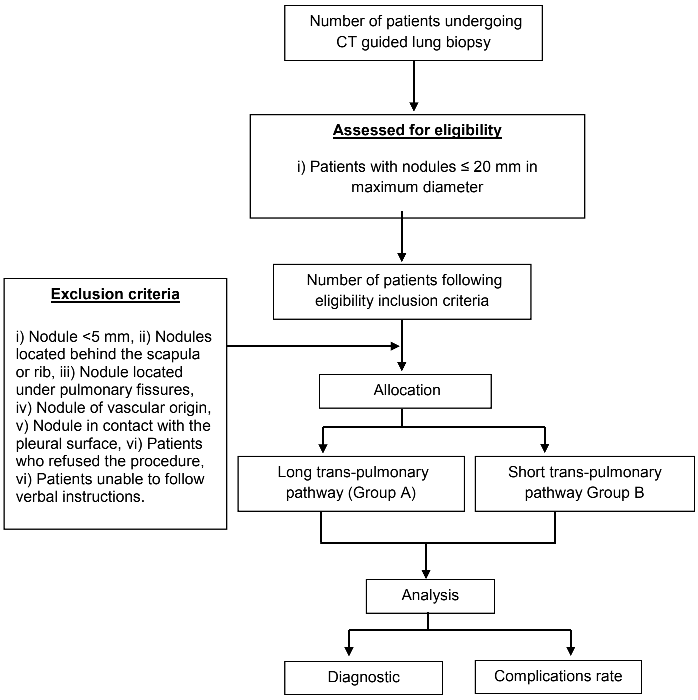

Figure 1: Flow diagram of research methodology

This was a prospective cross-sectional study consecutively enrolling patients with small pulmonary nodules at sub-pleural location undergoing CT guided biopsy at Radiology Department of Birat Medical College Teaching Hospital between September, 2024 and September, 2025. Small nodules were defined as nodule ≤ 20 mm in maximum diameter and sub-pleural nodules as nodules within 10 mm from pleura.[7] The exclusion criterias were as follows: i) Nodules <5 mm in maximum diameter, ii) Nodules located behind the scapula or ribs, iii) Nodules located under pulmonary fissures, iv) Nodules of vascular origin, v) Nodules in contact with the pleural surface, vi) Patients who refused the procedure, vii) Patients unable to follow verbal instructions.

Patients were divided into two different groups based on two different techniques for performing CT guided lung biopsy. Patients in whom indirect puncture (biopsy needle traversing a long distance, i.e., ≥ 10 mm of aerated lung) was performed to access the nodule were allocated as group A (long trans-pulmonary pathway group) and those in whom direct puncture (biopsy needle traversing a short distance, i.e., <10 mm of aerated lung) were allocated as group B (short trans-pulmonary pathway).[7] Figure 2. demonstrated two different biopsy approaches. Choice of technique was decided by the interventional radiologist according to the lesion size and the anatomical position of the lesion.

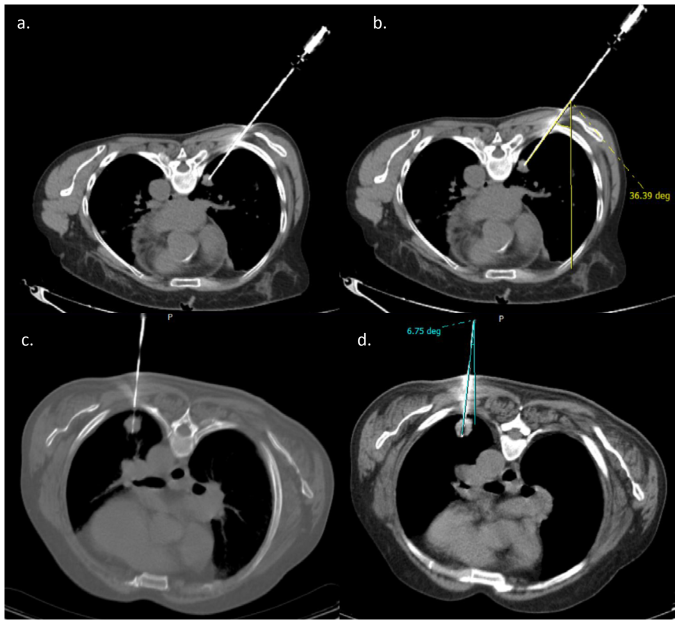

Figure 2: CT images demonstrating short and long trans-pulmonary pathway in obtaining biopsy sample from two different patients in prone position. Images in a. and b. shows indirect puncture approach (Group A) with needle projected to traverse as much as normal lung before reaching the lesion, thereby increasing the angle of needle pathway (36.4 °). Images in c. and d. show direct puncture approach (Group B) with needle projected almost parallel to bed/lesion (6.7°).

Two radiologists, experienced in interventional procedure, performed the CT guided biopsy on 128- section GE Revolution TM EVO CT scan machine. Depending on the lesion location, the patient was placed on the CT table in the either supine, prone, or lateral decubitus positions. Imaging parameters were 120 KVp, 280 mA, and 1.25 mm section thickness. The images were reviewed with a lung window setting (window width, 1500 HU; window level, -600 HU). A needle path was selected to avoid emphysema, bullae, blebs, fissures, and vascular structures during biopsy if possible. The site of puncture was aseptically prepared and draped, and approximately 3 ml of 1% xylocaine was administered for local anesthesia. Coaxial needle (18 G, Target Tru-cut, Huaxing Medical apparatus, Jiangsu, China) was inserted and when the needle tip reaches the lung lesion, the stylet was removed, and samples were obtained by cutting needle. Specimens obtained was fixed in 10% formalin solution and sent for histopathological evaluation. After the procedure, CT was performed to check for any post procedural complications.

Data was collected regarding demographic and clinical factors of patients and procedural factors from each group and was compared statistically.

Demographic and clinical characteristics of patient's lesion size and location, procedural factors including post procedural complication and pathological findings was recorded. Demographic characteristics of patients included gender and age. Clinical characteristics of patients included lesion size, lesion location, lesion-pleural distance, lesion necrosis, and the length of the needle path. Procedural factors included patient position, mean number of pleural punctures, complications and biopsy results.

All statistical analyses were performed using Statistical Package for the Social Science (SPSS) version 23.0 (IBM Corp., Armonk, NY, USA). Continuous variables were presented as the mean ± standard deviation and categorical variables were presented as percentages. For comparisons of clinical characteristics of the patients between the groups, independent t-test was used to compare continuous variables and a χ^2 test was used to compare categorical variables. Diagnostic accuracy and complication rates between the two groups was compared using χ^2 test. $P<0.05$ was considered as statistically significant difference.

RESULTS

A total of 65 patients with 65 pulmonary nodules were consecutively included in this study after applying the inclusion and exclusion criteria from September 2024 to September 2025. Depending upon the biopsy technique, 34 patients (mean age ± standard deviation (SD), 63.67 ± 9.30; range, 49 - 84; male/female, 22/12) were grouped into group A and 31 patients (mean age ± SD, 65.80±8.04; range, 54-82; male/female, 21/10) into group B. Clinical characteristics of patients between the two groups were statistically insignificant except for length of needle pathway which was significantly longer for group A compared to group B (p<0.001). The baseline clinical characteristics of all patients in each group are given in Table 1.

Table 1: Baseline characteristics of patients in both groups

Parameters	Group A	Group B	p-Value
Age (Years; mean±SD)	63.67 ± 9.30	65.80±8.04	0.32
Gender (Male/Female)	22/12	21/10	0.79
Lesion Size (mm; mean±SD)	15.4±3.5	14.9±3.8	0.57
Lesion distance from pleura (mm; mean±SD)	6.5±1.8	6.7±2.1	0.73
Lesion necrosis	12	8	0.41
Lesion Location			
Right upper lobe	9	7	
Right middle lobe	5	4	
Right lower lobe	5	6	0.98
Left upper lobe	6	6	
Left lower lobe	9	8	
Mean number of pleural punctures	1.2±0.5	1.1±0.3	0.32
Patient position			
Supine	18	12	
Prone	11	17	0.29
RLD	3	1	
LLD	2	1	
Length of needle pathway (mm; mean±SD)	23.6±6.5	5.3±1.7	<0.001*

Group A: Long transpulmonary pathway; Group B: Short transpulmonary pathway; RLD right lateral decubitus; LLD left lateral decubitus; *p<0.05 denotes statistical significance

Pathologically, out of 65 nodules, 53 were malignant and 12 were benign. Overall diagnostic accuracy of CT guided core needle biopsy was 89.2%. There was no significant difference in diagnostic accuracy between the two groups (Group A vs Group B: 91.2% Vs 87.1%; p=0.59). Similarly, neither difference in sensitivity nor negative predictive value was found significant between the two groups (Group A vs Group B: 88.8% vs 84.6% p=0.64 and 70.0% vs 55.5% p=0.26 respectively). There were three false-negative biopsy results in group A where two cases were diagnosed as necrosis, and one as fibrous tissue. In group B, there was four false negative results, of which two cases were diagnosed as necrosis, one as atypical cells and one as inflammatory. Diagnostic yield of both groups is shown in Table 2.

Table 2: Diagnostic accuracy of both groups

Variable	Group A	Group B	p-Value
Diagnostic accuracy (%)	91.2% (31/34)	87.1% (27/31)	0.59
True Positive (n)	24	22	NA
True Negative (n)	7	5	NA
False Positive (n)	0	0	NA
False Negative (n)	3	4	NA
Sensitivity (%)	88.8%	84.6%	0.64
Specificity (%)	100%	100%	NS
Positive predictive value (%)	100%	100%	NS
Negative predictive value (%)	70.0%	55.5%	0.26

Group A, Long transpulmonary pathway; Group B, short transpulmonary pathway; n: number; %: percentage; * p<0.05 denotes statistical significance

Procedure related complication rate

Pneumothorax rate was higher in group B (29.0%; 9/31) compared to group A was (14.7%; 5/34), however, statistically no significant difference between the two groups were found (p=0.16). Nevertheless, pneumothorax rate for lesion closer to pleura (<5mm) was significantly higher in group B (85.7%) compared to group A (16.6%) (p=0.01). Moreover, for lesions in which ≥2 pleural passes were made, pneumothorax rate was higher in group B (100%) compared to group A (57.1%) (p=0.01). Furthermore, pneumothorax rate for smaller lesion (5-10 mm) was significantly higher in group B (71.4%) compared to group A (40%) (p-value=0.02). Post-procedural hemorrhage rate was 20.5 % in group A and 6.4 % in group B. Statistically difference between two groups was insignificant (p=0.09). Hemorrhage was observed more for smaller lesion (5-10 mm) in group A (100%) compared to group B (28.5%) (p=0.01). Similarly, lesion in which ≥2 pleural passes were made had higher hemorrhage rate in group A (100%) compared to group B (50%) (p=0.04). Post-procedural complications rate is shown in Table 3 and Table 4.

Table 3: Procedural complication in both groups

Complications	Group A	Group B	p-Value
Pneumothorax	5 (14.7%)	9 (29.0%)	0.16
Hemorrhage	7 (20.5%)	2 (6.4%)	0.09
Chest tube placement	0	0	

Group A: Long transpulmonary pathway; Group B: Short transpulmonary pathway

Table 4: Correlation of pneumothorax and hemorrhage rate in both groups with various risk factors

Parameters	Pneumothorax			Hemorrhage		
	Group A	Group B	p-value	Group A	Group B	p-value
Lesion size (mm)						
5-10	2(40%)	5(71.4%)	0.023*	5(100%)	2(28.5%)	0.01*
11-20	3(10.3%)	4(16.6%)	0.004*	2(6.8%)	0	0.19
p-Value	0.15	0.012		0.000	0.013	
Lesion distance from pleura						
<5mm	1(16.6%)	6(85.7%)	0.01*	1 (16.6%)	0	0.26
5-10 mm	4(14.2%)	3 (12.5)	0.85	6 (21.4%)	2 (8.3%)	0.19
p-Value	0.8	0.001		0.79	0.43	
Number of pleural punctures						
1	1 (3.7%)	5(18.5%)	0. 08	0	0	NS
≥2	4(57.1%)	4 (100%)	0.02*	7(100%)	2(50%)	0.04*
p-Value	0.003	0.001		0.000	0.000	

Group A: Long transpulmonary pathway; Group B: Short transpulmonary pathway;*p<0.05 denotes statistical significance

DISCUSSION

Only few studies have compared short versus long trans-pulmonary biopsy approaches for small sub-pleural pulmonary nodules and the findings are contradictory.[7-10] While some studies reported long trans-pulmonary approach to be associated with higher pneumothorax rate with possible explanation presented as larger area of the lung parenchyma being pierced by needle,[2,11-14] other studies reported lower pneumothorax rate for long trans-pulmonary pathway biopsy approach compared to short trans-pulmonary approach.[4,7,9,10]

Herein the present study, although overall pneumothorax rate was higher for short trans-pulmonary pathway (29.0%) compared to long trans-pulmonary pathway (14.7%), difference was statistically insignificant which is in accordance with previous studies.[7-10] Similar to present study, Tanaka et al.[8] reported pneumothorax rate of 20% with short trans-pulmonary approach, compared with a 12.5% pneumothorax rate with a longer trans-pulmonary approach but with insignificant difference statistically. Yu et al.[7] and Wallace et al.[10] also found no significant difference in pneumothorax rate between short and long trans-pulmonary approaches. In a study by Yu et al.[7] 11.6% of the case (19/164) had pneumothorax in long pathway group while in short pathway group 8.5% (6/74) cases had pneumothorax (p=0.47). In a study by Wallace et al.[10] 15/21 (71%) cases in long and 6/11 (55%) case in short pathway group had pneumothorax. Gupta et al.[9] also reported insignificant difference in pneumothorax rate with use of either of approaches, however, chest tube insertion was higher with the use of long-needle path biopsy (38% vs 17%, p=0.006). Possible explanation could be that when larger segment of aerated lung is traversed as with long trans-pulmonary pathway approach more air leakage occur as compared to short segment of aerated lung being traversed. On further analysis, lesion-pleura distance and number of pleural passes attributed to higher pneumothorax rate for short trans-pulmonary pathway in the present study. Use of short trans-pulmonary biopsy approach for lesion closer to pleura (<5mm) increases pneumothorax rate significantly compared to long trans-pulmonary approach (85.7% Vs 16.6%; p=0.01). Furthermore, if ≥2 pleural passes were made to access these sub-pleural lesions with short trans-pulmonary approach pneumothorax rate further shoots up and was significantly higher compared to long trans-pulmonary pathway (100% Vs 57.1%; p=0.01). Although above mentioned studies did not look for correlation between lesion-pleural distance or number of pleural passes and pneumothorax rate, many other previous studies have reported lesion-pleural distance or number of pleural passes as a factor associated with higher pneumothorax rate.[14-20] While some studies[15-18] reported increase in pneumothorax rate with increase in lesion distance from pleura, other studies found no such correlation.[14,19,20]

Yeow et al.[19] reported that rate of pneumothorax for sub-pleural nodule (lesion located 10-20 mm from pleura) was approximately seven times higher than lesions abutting the pleural surface and lesions located > 20 mm from pleural surface. In another study Yeow 2004 et al.[4] reported sevenfold higher risk of pneumothorax in lesions located 10-20 mm from pleura while this risk drops down to 4.4-fold for lesion > 20 mm form the pleura. Cox et al.[20] reported 50% pneumothorax rate for lesion located <20 mm from pleural surface with no increment in rate with increase in lesion distance from pleural surface. Furthermore, Ohno et al.[14] reported higher pneumothorax rates with higher number of pleural passes 18%, 53%, and 73% pneumothorax rate for one, two and three pleural passes respectively. Present study also found lesion size to correlate with higher pneumothorax rate. In short trans-pulmonary pathway group 71.4% of cases with smaller lesion (5-10 mm) had pneumothorax while 40% of the cases had pneumothorax in long trans-pulmonary group. This finding was consistent with previous studies reporting pneumothorax rate increment with decrement in lesion size. In a study by Gupta et al.[9] pneumothorax rate was 90% with the use of short pathway approach while with the use of long pathway approach 75% cases had pneumothorax. Cox et al.[20] reported 64% pneumothorax rate for lesion <20 mm and 41% for lesion >20 mm. Kazerooni et al.[18] reported higher pneumothorax rate for smaller and deeper lesion (lesion-pleura distance).

In the present study, post procedural hemorrhage rate was 20.5% in long trans-pulmonary group and 6.4% in short trans-pulmonary group, suggesting larger the area of lung parenchyma traversed by needle more the possibility of hemorrhage which is consistent with previous findings.[7,9] Yu et al.[7] reported significantly higher post procedural hemorrhage rate (22.0%) with use of long pathway approach compared to use of short pathway approach (9.9%) ($p=0.02$). Gupta et al.[9] reported 76% versus 35% hemorrhage rate ($p<0.001$) for long versus short trans-pulmonary approach. Higher post-procedural hemorrhage using long pathway is expected as longer distance along the lung parenchyma means more blood vessels along the course that can be injured.

Regarding diagnostic accuracy, no significant difference between the two approaches was noted in the present study. Few studies have reported better diagnostic yield with long trans-pulmonary pathway especially for smaller lesion.[8-10] Tanaka et al.[8] reported significantly higher diagnostic yield with use of long trans-pulmonary approach (81.2%) compared to short trans-pulmonary approach (43.3%) for lesion smaller than 20 mm. Wallace et al.[10] also found long pathway to be effective compared to short pathway approach for sampling small (up to 10 mm) sub-pleural nodules. Similar findings were reciprocated by Gupta et al.[9] with significant difference in diagnostic yield 94% versus 40% for long versus short pathway approach respectively in sampling smaller lesion (0-10 mm). Several factors in our study might have resulted in insignificant difference in diagnostic yield for both approaches, for instance lesser number of patients in both group, exclusion of sub-pleural lesion behind scapula and ribs, only sub-pleural nodule (<20 mm) excluding deeper lesion, and radiologist/pathologist technical factors.

Admittedly, there are several limitations to the present study. The study used consecutive sampling technique which was a non-random selection method inherently risking selection bias. Moreover, this was a single center study where the number of patients included is small, and therefore the power to detect differences in outcome may be insufficient. Furthermore, choice of biopsy approach solely depends upon performing radiologist preference and therefore, could have been affected the results, nevertheless strict inclusion criteria in both groups (similar lesion size, lesion-pleural distance etc.) must have ensured statistically meaningful comparison between the two groups.

CONCLUSIONS

Long transpulmonary pathway had similar diagnostic yield for small (20 mm) sub- pleural pulmonary lesions, however with lesser pneumothorax rate compared to short transpulmonary pathway. Lesion size, lesion pleural distance and number of passes together increases the risk pneumothorax in sub- pleural pulmonary lesions. Therefore, small subpleural lesions may require long transpulmonary pathway approach to ensure better manipulation of needle to obtain adequate sample without complicating the procedure with pneumothorax. However, further multicenter studies with larger sample sizes are warranted to validate findings of the present study.

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AUTHORS' CONTRIBUTIONS

The concept was designed by SKD; the literature search was conducted by SC, MRP, and AP; data were collected by MRP and AP; data analysis was performed by SKD and SC; manuscript was drafted by SKD; all authors revised and approved the final version, taking full responsibility for its content.

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