Section: Radiodignosis

Original Research Article

INCIDENCE AND RISK FACTORS FOR PNEUMOTHORAX FOLLOWING CT-GUIDED LUNG BIOPSY: AN ANALYSIS OF LESION RELATED AND TECHNICAL FACTORS

Mathew Koshy[1], Anand Krishna Dev C[2], Danny Jose Titus[3], Sharon Elsa John[4], Haritha S[5]

[1]Assistant Professor, Department of Radiodignosis, Believers Church Medical College, Thiruvalla, India.
[2]Assistant Professor, Department of Radiodignosis, Believers Church Medical College, Thiruvalla, India.
[3]Associate Professor, Department of Radiodignosis, Believers Church Medical College, Thiruvalla, India.
[4]Senior Resident Department of Radiodignosis, Believers Church Medical College, Thiruvalla, India.
[5]Junior Resident, Pushpagiri Institute of Medical Sciences, Thiruvalla, India

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Corresponding Author:
Dr. Mathew Koshy,
Email: mathewkoshy2003@gmail.com

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ABSTRACT

Background: Computed tomography (CT)-guided lung biopsy is a crucial tool for confirming the nature of lung lesions[1]. Pneumothorax is a common complication of this procedure[2]. Identifying risk factors for pneumothorax is essential for optimizing patient safety and procedural planning. This study aimed to determine the incidence of pneumothorax following CT-guided lung biopsy and assess the association between various lesion related and technical factors and its occurrence. **Materials and Methods:** This prospective observational study included 48 patients who underwent CT-guided lung biopsy at a tertiary care center between January 2018 and June 2019. Data on lesion related characteristics (size, depth from chest wall, side/lobe location) and technical factors (number of needle passes, fissure crossing) were collected from CT images and procedural records. The occurrence of pneumothorax post-biopsy was recorded. Statistical analysis using the Chi-square test was performed to assess the association between these factors and the development of pneumothorax. **Result:** Pneumothorax occurred in **54.2%** (26 out of 48) of the biopsies. Statistical analysis revealed a **significant association** between the **depth of the lesion from the chest wall** and the occurrence of pneumothorax (p=0.040). Specifically, **69.6%** of lesions located at a depth of 2 cm or more from the chest wall developed pneumothorax, compared to **40.0%** of lesions located less than 2 cm deep. No significant association was found between pneumothorax and lesion size (p=0.790), side/lobe location (p=0.499), or fissure crossing (p=0.864). All procedures in this study involved four needle passes, precluding the analysis of this factor as a variable.

Conclusion: The incidence of pneumothorax in this study was high. Lesion depth from the chest wall was identified as a significant risk factor for pneumothorax following CT-guided lung biopsy, with deeper lesions associated with a higher incidence. These findings underscore the importance of considering lesion depth during pre-procedural planning to anticipate and potentially mitigate the risk of pneumothorax. Further research with larger sample sizes and variable technical factors is warranted to validate these findings and explore other potential risk factors.

INTRODUCTION

Lung cancer is the leading cause of cancer-related deaths worldwide among both males and females.[3] In India, the prevalence and mortality rates of lung cancer follow a similar trend. Pulmonary nodules, often detected incidentally on Computed Tomography (CT) scans, can represent early-stage lung cancer. CT provides a detailed anatomical and morphological description of lung lesions, aiding in the differentiation between benign and malignant etiologies compared to plain radiography.[4,5]

CT-guided lung biopsy has become an indispensable tool for confirming the diagnosis and nature of suspicious lung lesions identified on imaging. The clarity offered by CT imaging regarding lesion location and accessible routes simplifies the procedure and enhances its precision and safety. However, this invasive procedure is associated with potential complications, the most common being pneumothorax, followed by pulmonary hemorrhage.[6]

Pneumothorax, the presence of air in the pleural space, is reported to occur in approximately 20% of patients undergoing CT-guided lung biopsy in some studies. The development of pneumothorax can range from minimal and asymptomatic to large and symptomatic, occasionally requiring chest tube insertion.[2] Understanding the factors that contribute to the risk of pneumothorax is crucial for optimizing patient selection, refining procedural techniques, and minimizing morbidity associated with CT-guided lung biopsy.

Several lesion related characteristics, such as the size and depth of the lesion, as well as technical factors related to the biopsy procedure, including the route of needle insertion and the number of attempts, have been hypothesized to influence the risk of complications. However, the precise relationship between these factors and the occurrence of pneumothorax remains a subject of ongoing investigation.[7,8]

This study aimed to prospectively investigate the incidence of pneumothorax following CT-guided lung biopsy in a cohort of patients at a tertiary care center in central Kerala. The primary objectives were to:

1. To determine the incidence of pneumothorax following CT-guided lung biopsy in our study population.
2. To assess the association between various lesion related factors (size, depth from chest wall, side/lobe location) and the occurrence of pneumothorax.
3. To assess the association between technical factors (number of needle passes, fissure crossing) and the occurrence of pneumothorax.

By identifying potential risk factors for pneumothorax, this study seeks to contribute to a better understanding of the safety profile of CT-guided lung biopsy and inform strategies to mitigate this common complication.

MATERIALS AND METHODS

Study Design and Setting

This study employed an observational cross-sectional design, conducted in the Department of Radiodiagnosis at Pushpagiri Institute of Medical Sciences and Research Centre, Thiruvalla, Kerala. The study was carried out over a period of 18 months, from January 2018 to June 2019. Approval from the Institutional Ethics Committee was obtained prior to the commencement of the study.

Study Population and Sampling

The study population comprised patients referred to the Department of Radiodiagnosis for CT-guided lung biopsy following an initial CT scan of the thorax. A non-probability consecutive sampling technique was used to recruit eligible patients. The inclusion criterion was the provision of informed consent by patients for their results to be used in the study. Exclusion criteria included patients with a history of previous lung resection, hydatid or cystic lung disease, coagulopathies, pulmonary arterial hypertension, respiratory failure, those on anticoagulants or mechanical ventilation, seropositive patients, and those unable to cooperate with the study procedures.

CT-Guided Lung Biopsy Procedure

All CT-guided lung biopsies were performed using a GE Healthcare Optima CT660 128 slice CT scanner. Prior to the procedure, informed consent was obtained, and relevant pre-biopsy investigations, including platelet count, prothrombin time, activated partial thromboplastin time (APTT), and bleeding and clotting time, were reviewed. Patients taking anticoagulation or antiplatelet medications were advised to discontinue them prior to the procedure.

Patients were positioned prone or supine based on the location of the lesion and the preferred skin entry site. Biopsies were not performed with the patient in a sitting position to minimize the risk of air embolism. Patients were instructed on breath-holding techniques to minimize respiratory motion during needle insertion.

A marker was placed on the skin surface at the estimated entry point, and a check CT scan was performed to assess its proximity to the lesion. The entry point was then marked on the patient's skin using the CT scanner's laser guidance system. The depth of needle insertion was calculated from the initial CT images, ensuring avoidance of major vessels or bullae along the needle path.

The skin entry site was sterilized, and local anesthesia (2% lignocaine, up to 20 ml) was administered, taking care not to reach the pleural level. A small skin nick was made to facilitate needle insertion. A 16-gauge introducer needle was used with a coaxial technique, and an 18-gauge automatic cutting needle was passed through it. Needle insertion and firing were performed during complete breath-hold. In all cases included in this study, four needle passes were performed from the same lesion, with rotation of the biopsy gun between each sample to obtain tissue from different directions. The stylet valve was closed between samples to minimize iatrogenic air entry[9].

Following sample collection, the needles were removed, and manual pressure was applied to the wound site. Patients were monitored in the emergency department for at least 6 hours post-biopsy. A check erect chest X-ray or CT scan was performed at the end of the monitoring period to assess for procedure-related thoracic complications, specifically pneumothorax and haemorrhage.

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Patients were also informed about the possibility of delayed complications prior to discharge[9].

Sample Size

Assuming sensitivity of 94% and specificity of 33.3% from previous study. Type 1 error α as 5% and desired precision as 10%, the sample size is calculated as 48.

The formula is n = (Zα)2 × P (1-P)/d2 Where n= (a+c)/ prevalence, if we consider sensitivity and n=(b+d)/1- prevalence, if we consider specificity.

Data Collection

Data on patient demographics, lesion related characteristics, technical factors of the biopsy, and post-biopsy complications were prospectively collected and recorded in a patient proforma.

Lesion related factors assessed included:

- **Size of the lesion:** Measured as the maximum dimension on the CT scan and categorized as ≤ 5 cm or > 5 cm.
- **Depth of the lesion from the chest wall:** Measured as the shortest distance from the outer margin of the lesion to the inner surface of the chest wall at the entry point, categorized as < 2 cm or ≥ 2 cm.
- **Side and lobe of the lesion:** Recorded as left lower lobe, right lower lobe, left upper lobe, right upper lobe, or bilateral.

Technical factors assessed included

- **Number of needle passes:** Recorded for each procedure. In this study, all cases had 4 needle passes.
- **Fissure crossing:** Documented based on whether the biopsy needle traversed a pulmonary fissure during the procedure, categorized as yes or no.

The occurrence of pneumothorax post-biopsy was documented based on the findings of the follow-up chest X-ray or CT scan. The severity of pneumothorax was not graded in this study; its presence or absence was the primary outcome variable for this analysis.

Statistical Analysis

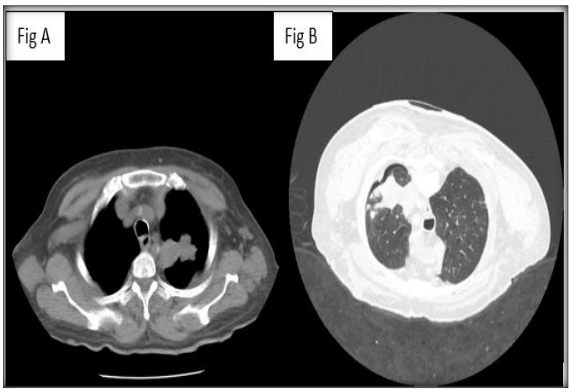
Statistical analysis was performed using SPSS version 20.0. Categorical variables were expressed as frequencies and percentages. The Chi-square test was used to assess the association between the categorical lesion related and technical factors (lesion size, depth, side/lobe, fissure crossing) and the occurrence of pneumothorax. A p-value of less than 0.05 was considered statistically significant. Due to all cases having four needle passes, this variable could not be analysed for its association with pneumothorax in this study.

RESULTS

The study population consisted of 48 patients who underwent CT-guided lung biopsy. The mean age of the patients was not specified in the provided excerpts.

Incidence of Pneumothorax

Post-biopsy pneumothorax occurred in 26 out of the 48 cases, representing an incidence of 54.2%.



Axial non contrast CT scan showed a lobulated mass lesion in the left upper lobe (Fig A). There was occurrence of minimal pneumothorax during the procedure (Fig B). The biopsy report came as small cell carcinoma.

Association between lesion related Factors and Pneumothorax

- **Lesion Size:** Among the 25 lesions ≤ 5 cm in maximum dimension, 14 (56.0%) developed pneumothorax, while 11 (44.0%) did not. In the 23 lesions > 5 cm, 12 (52.2%) developed pneumothorax, and 11 (47.8%) did not. The Chi-square test revealed no significant association between lesion size and the occurrence of pneumothorax ($\chi^2 = 0.07$, $p = 0.790$).
- **Depth of Lesion from Chest Wall:** Of the 25 lesions located < 2 cm from the chest wall, 10 (40.0%) were associated with pneumothorax, and 15 (60.0%) were not. In the 23 lesions located ≥ 2 cm from the chest wall, 16 (69.6%) developed pneumothorax, and 7 (30.4%) did not. The Chi-square test demonstrated a **statistically significant association** between the depth of the lesion and the occurrence of pneumothorax ($\chi^2 = 4.22$, $p = 0.040$).

Side and Lobe of Lesion: The distribution of pneumothorax across different lung locations was as follows: Left lower lobe (2/5, 40.0%), Right lower lobe (5/7, 71.4%), Left upper lobe (10/21, 47.6%), Right upper lobe (9/14, 64.3%), and Bilateral (0/1, 0.0%). The Chi-square test showed no significant association between the side/lobe of the lesion and the occurrence of pneumothorax ($\chi^2 = 3.37$, $p = 0.499$).

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Table 1: Association between lesional and technical factors, and the occurrence of Pneumothorax during CT guided lung biopsy

		Pneumothorax				χ^2	p
		Present		Absent			
		Count	Percent	Count	Percent		
Size	**<=5**	14	56.0	11	44.0	0.07	0.790
	>5	12	52.2	11	47.8		
Depth	**<2**	10	40.0	15	60.0	4.22*	**0.040**
	>=2	16	69.6	7	30.4		
Side/Lobe	**Left LL**	2	40.0	3	60.0	3.37	0.499
	Right LL	5	71.4	2	28.6		
	Left UL	10	47.6	11	52.4		
	Right UL	9	64.3	5	35.7		
	Bilateral	0	0.0	1	100.0		
Fissure	**Nil**	22	53.7	19	46.3	0.03	0.864
	Yes	4	57.1	3	42.9		

: - Significant at 0.05 level

Association between Technical Factors and Pneumothorax

- **Number of Needle Passes:** All 48 cases underwent four needle passes. Therefore, the association between the number of needle passes and pneumothorax could not be statistically analyzed in this study.

Fissure Crossing: In the 41 cases where fissure crossing was not required, 22 (53.7%) developed pneumothorax, and 19 (46.3%) did not. Among the 7 cases requiring fissure crossing, 4 (57.1%) developed pneumothorax, and 3 (42.9%) did not. The Chi-square test revealed no significant association between fissure crossing and the occurrence of pneumothorax ($\chi^2 = 0.03$, $p = 0.864$).

DISCUSSION

This prospective study of 48 patients undergoing CT-guided lung biopsy revealed a high incidence of post-procedural pneumothorax (54.2%). This incidence is within the expected range reported in some previous literature.[10] Our study found a statistically significant association between the depth of the lung lesion from the chest wall and the occurrence of pneumothorax, with deeper lesions (≥ 2 cm) being associated with a higher risk.

The finding that deeper lesions are more likely to result in pneumothorax is plausible. The increased distance the needle traverses through lung parenchyma in deeper lesions may increase the likelihood of lacerating visceral pleura, leading to air leakage into the pleural space. Additionally, the greater tissue path may result in more parenchymal disruption, potentially increasing the risk of air tracking along the needle path to the pleural surface. Our observation that 69.6% of lesions located at a depth of 2 cm or more developed pneumothorax highlights the importance of considering this factor during pre-procedural risk assessment and planning.

In agreement with some previous studies, our study also did not find a significant association between lesion size and the risk of pneumothorax11. While larger lesions might theoretically involve a greater tissue volume and potentially a higher risk of parenchymal damage, our data did not support this association. Similarly, the side and lobe of the lesion did not significantly influence the incidence of pneumothorax in our cohort. This suggests that other factors, such as the anatomical location's influence on respiratory movement or pleural adherence, may not have played a dominant role in our study.

Fissure crossing during the biopsy procedure was also not found to be significantly associated with pneumothorax in our analysis. While crossing a fissure might be considered a potential risk factor due to the presence of two pleural layers, our findings did not demonstrate a statistically significant increase in pneumothorax risk in these cases.

A notable limitation of our study is that all included procedures involved four needle passes. This standardized technical factor, while ensuring adequate tissue sampling in most cases, prevented us from analysing the potential impact of the number of needle passes on the incidence of pneumothorax. Previous studies have suggested that a higher number of needle passes might increase the risk of complications, including pneumothorax, due to increased mechanical trauma to the lung tissue and pleura.[12] Future research should explore the influence of varying numbers of needle passes on pneumothorax risk.

Another potential limitation is the relatively modest sample size of 48 patients, which might have limited the statistical power to detect significant associations for some of the analysed factors. Larger multi-centre studies with diverse patient populations and procedural variations are needed to further validate our findings and identify other potential risk factors for pneumothorax following CT-guided lung biopsy.

Despite these limitations, our study provides valuable insights into the incidence and risk factors for pneumothorax in our specific clinical setting. The significant association identified between lesion depth from the chest wall and the risk of pneumothorax has direct implications for procedural planning and patient counselling. Radiologists performing CT-guided lung biopsies should be particularly mindful of the depth of the target lesion and consider strategies to minimize pleural trauma, especially in cases of deeper lesions. These strategies might include using smaller gauge needles when

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feasible, employing coaxial techniques judiciously, and carefully monitoring patients post-procedure, particularly those with deeply located lesions.

CONCLUSION

This prospective study found a high incidence of pneumothorax (54.2%) following CT-guided lung biopsy. A statistically significant association was observed between the depth of the lung lesion from the chest wall and the occurrence of pneumothorax, with lesions located deeper than 2 cm demonstrating a higher risk. No significant associations were found between pneumothorax and lesion size, side/lobe location, or fissure crossing in this study. The standardized use of four needle passes precluded the analysis of this technical factor as a variable.

These findings highlight the importance of considering lesion depth as a significant risk factor for pneumothorax during pre-procedural planning for CT-guided lung biopsy. Further research with larger and more diverse cohorts, including the evaluation of the impact of varying technical factors, is warranted to refine our understanding of the risk factors for this common complication and to develop strategies for its prevention and management.

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