Journal of Carcinogenesis
Covering Genesis to Therapeutics

Journal of Carcinogenesis, ISSN: 1477-3163
2025; Vol 24: Issue 4s, https://carcinogenesis.com/

# Analysis of Incidence of Pneumothorax and its Risk Factors after Transthoracic Biopsy of Lung Lesions under CT Guidance

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## ABSTRACT

**Background**: Pneumothorax is a recognized complication of CT-guided transthoracic lung biopsy. Identifying contributing risk factors is crucial to enhance procedural safety.

**Material and Methods**: This study analyzed 500 patients undergoing CT-guided transthoracic lung biopsies, evaluating variables such as age, lesion depth, and number of needles passes in relation to pneumothorax development.

**Results**: The incidence of pneumothorax was 21.2%. Deeper lesions and more than two needle passes were significantly associated with increased risk, while age and sex showed no statistical correlation.

**Conclusion**: Attention to modifiable procedural factors, especially lesion depth and needle passes, can reduce pneumothorax risk in CT-guided lung biopsies.

***Keywords:*** *Pneumothorax, CT-guided biopsy, Lung lesions, Risk factors*

**How to Cite:** Dr. P. R. Gokulakrishnan, Dr. J.D. Roy Santhosham, Dr. Arunan Murali, Dr Siddharth Tewari, (2025) Analysis of Incidence of Pneumothorax and its Risk Factors after Transthoracic Biopsy of Lung Lesions under CT Guidance, *Journal of Carcinogenesis*, *Vol.24, No.4s*, 928-934

## 1. INTRODUCTION

Computed tomography (CT)-guided transthoracic lung biopsy is widely utilized to obtain histologic diagnoses of peripheral lung lesions due to its high diagnostic utility and efficiency. Despite its effectiveness, it is not without complications, and pneumothorax remains the most frequent adverse event, with incidence rates reported between approximately 9% and 54%, averaging around 20–26% among contemporary studies [1][2]. Notably, haemoptysis and pneumothorax often co-occur, with complication rates nearing 27.6% in some cohorts, and chest tube insertion required in up to 6.6% of cases [3].

Risk stratification has been refined through meta-analyses and observational studies. Significant predictors of pneumothorax include the presence of emphysema, deeper lesion location, smaller lesion size, lesions without pleural contact, and prolonged needle path traversing lung parenchyma [1][4]. Patient positioning during biopsy is also critical: procedures performed with the biopsy lung dependent in the lateral decubitus position result in significantly lower pneumothorax rates compared to supine, prone, or with the biopsy lung non-dependent [1]. Techniques such as normal saline tract sealing combined with rapid post-biopsy rollover to the puncture-site down position have demonstrated a marked reduction in chest tube–requiring pneumothoraces, despite only modest decreases in overall pneumothorax incidence [5].

Emerging to enhance procedural safety, advanced imaging tools like minimum intensity projection (MinIP) reconstructions and radiodensity mapping have shown promise in predicting pneumothorax risk by quantifying virtual pathways and tissue characteristics—allowing pre-procedural planning to avoid high-risk trajectories [6]. In addition, comprehensive systematic reviews have reinforced the protective effects of positioning strategies, needle gauge selection, coaxial sampling

techniques, and limiting transgression of fissures or bullae [7].

In recent prospective efforts, real-time guidance protocols incorporating patient-specific lung compliance and diaphragmatic excursion monitoring have further helped reduce iatrogenic complications [8]. A notable advancement is the integration of post-biopsy low-dose CT surveillance to detect small asymptomatic pneumothoraces early, thereby enabling same-day discharge for stable patients [9]. Furthermore, institutional practices, including operator experience, biopsy needle dwell time, and use of coaxial versus single-needle systems, have all been linked to outcome variability [10].

In summary, the existing evidence delineates clear procedural and patient-related factors linked to pneumothorax following CT-guided thoracic biopsies. However, many studies remain retrospective or focused on single-institution cohorts. There is a pressing need for prospective, multicenter analyses with standardized protocols to better quantify such risks and guide preventive strategies. The present study, therefore, aims to determine the incidence of pneumothorax post-procedure and evaluate modifiable and non-modifiable risk factors, including imaging features, procedural technique, and post-biopsy maneuvers, with the goal of optimizing biopsy safety and patient outcomes.

## 2. MATERIAL AND METHODS

This prospective observational study was conducted over a defined period in a tertiary care teaching hospital with the aim of evaluating the incidence of pneumothorax and its associated risk factors following CT-guided transthoracic lung biopsy. A total of 500 patients who underwent CT-guided percutaneous biopsy for pulmonary lesions were included in the study. Inclusion criteria encompassed patients aged above 18 years with radiologically detectable lung lesions indicated for histopathological diagnosis via transthoracic biopsy. Patients with severe respiratory distress, uncorrectable coagulopathy, or those who declined consent were excluded from the study.

All procedures were performed using multislice computed tomography scanners under strict aseptic precautions. (Figure 1) Patients were positioned based on lesion location, most commonly in the supine, prone, or lateral decubitus positions to facilitate a direct, shortest, and safest needle path. Local anesthesia was administered and a coaxial needle technique was utilized in most cases. Needle gauge (18G or 20G), number of pleural punctures, depth of lesion from pleura, and number of samples taken were documented for each procedure. (Figure 3 to 5) Post-procedural imaging was performed immediately and after 2 hours to assess for any complications, particularly pneumothorax. (Figure 6)


**Figure 1: Multislice computed tomography scanners**

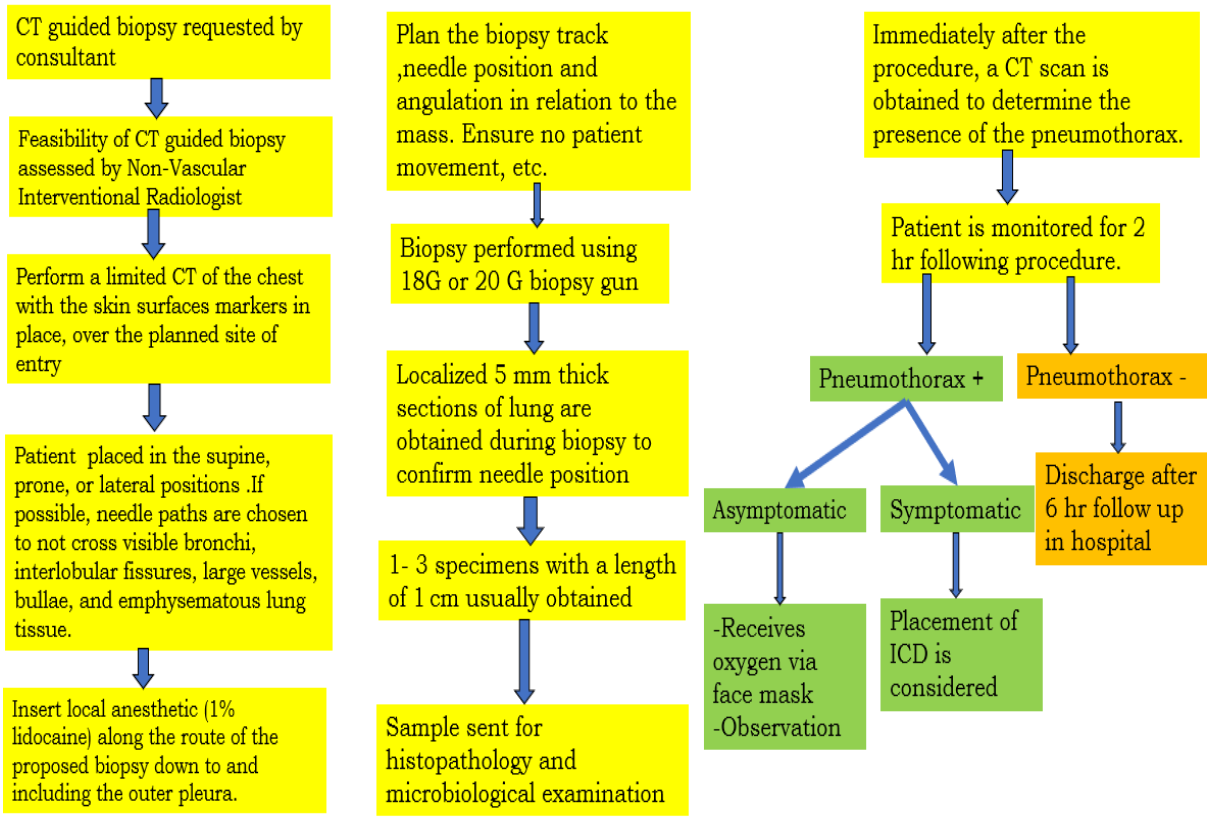


**Figure 2: Protocol for CT guided lung biopsy followed in our hospital**

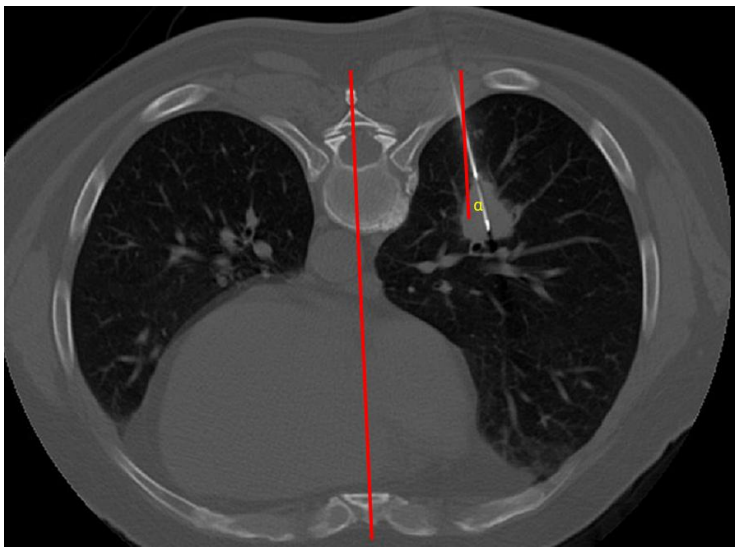


**Figure 3: Measurement of angle of needle trajectory**

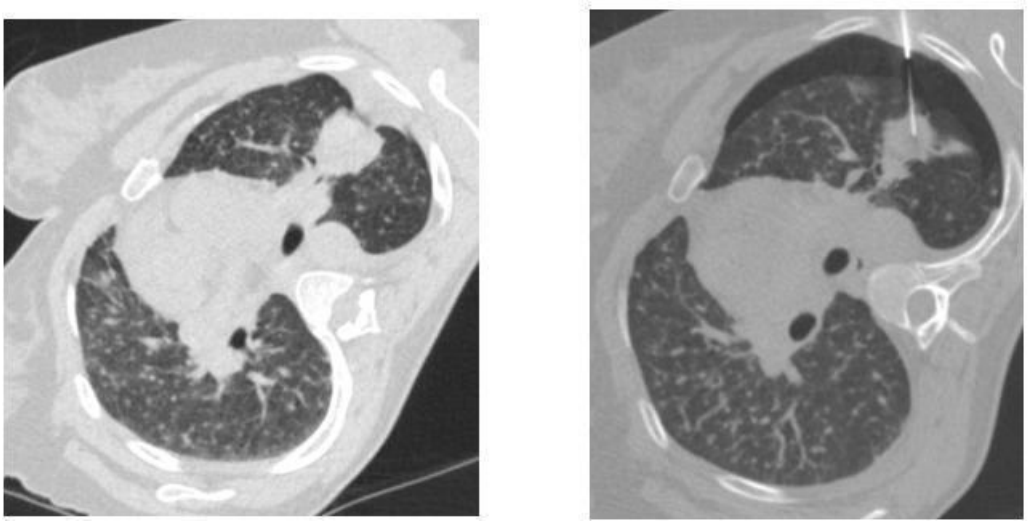

**Figure 4: CT Guided biopsy of Lesion of left upper lobe, Patient developed moderate pneumothorax**

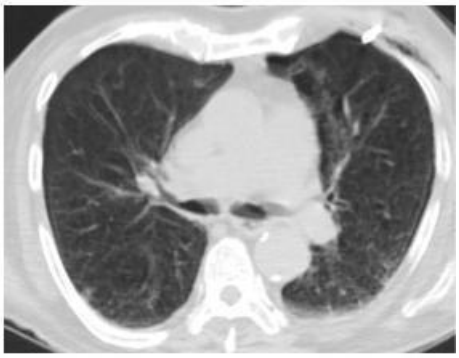

**Figure 5: ICD was inserted and air was aspirated**

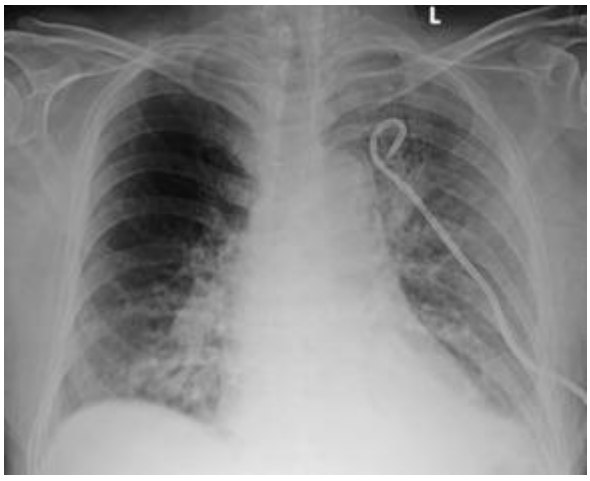


**Figure 6: Chest X ray done the next day shows complete resolution of pneumothorax. ICD in situ**

Pneumothorax was defined radiologically and classified as mild, moderate, or severe based on the extent of lung collapse. Management protocols were followed accordingly, ranging from conservative observation to intercostal drain placement in cases with respiratory compromise or progression on follow-up imaging. The study also documented the presence of underlying lung conditions such as emphysema or bullous disease, as well as lesion size, location, and proximity to major fissures.

Demographic data, clinical details, imaging findings, procedural parameters, and post-procedural outcomes were recorded in a structured pro forma. All patients provided informed written consent prior to inclusion in the study. Data analysis was performed using SPSS version 25.0. Descriptive statistics were used to express quantitative variables as mean ± standard deviation, and categorical variables as frequencies and percentages. Univariate and multivariate logistic regression analyses were carried out to determine independent risk factors associated with the development of pneumothorax. A p-value of less than 0.05 was considered statistically significant.

## 3. RESULTS

Table 1 illustrates the age distribution of the 500 patients who underwent CT-guided transthoracic biopsy. Of these, 253 (50.60%) were aged 60 years or younger, while 247 (49.40%) were above 60 years. The mean age was 59.41 ± 12.1 years, with the median age at 60 years, and an interquartile range of 52 to 68 years. The youngest patient was 23 years old and the oldest was 84, indicating a fairly wide age range among the participants.

Table 2 presents the overall incidence of pneumothorax among the study participants. Out of 500 cases, 106 patients developed pneumothorax post-biopsy, accounting for 21.2% of the total sample, while the remaining 394 patients (78.8%) did not experience this complication. These finding underscores pneumothorax as a common and noteworthy complication of transthoracic lung biopsies.

Table 3 compares the occurrence of pneumothorax between two age groups: those aged ≤60 years and those >60 years. Among younger patients, 49 developed pneumothorax and 204 did not, while among older patients, 57 developed pneumothorax and 190 did not. Although a slightly higher frequency of pneumothorax was observed in patients older than 60, the association was not statistically significant (p = 0.391), suggesting that age alone may not be a strong predictor of pneumothorax in this population.

Table 4 examines the relationship between the depth of the lesion from the pleural surface and the incidence of pneumothorax. A significantly higher incidence was observed in lesions located deeper than 1.5 cm from the pleura, with 82 patients developing pneumothorax in this group compared to only 24 in the group with lesions closer to the pleural surface (≤1.5 cm). The p-value of 0.001 indicates a strong statistical association, suggesting that deeper lesions substantially increase the risk of pneumothorax.

Table 5 explores the impact of the number of needle passes on pneumothorax occurrence. Of the 204 patients who required only a single needle pass, only 13 developed pneumothorax. This proportion increased with the number of passes: 22 pneumothoraces occurred among 135 patients who had two passes, and a striking 71 out of 161 patients who underwent three or more passes developed pneumothorax. The highly significant p-value of 0.001 implies a clear correlation between increased needle manipulation and higher risk of pneumothorax.

**Table 1: Distribution of Age (years) of Study Subjects**

| Age (years) | Frequency | Percentage |
|---|---|---|
| ≤60 | 253 | 50.60% |
| >60 | 247 | 49.40% |
| Mean ± SD | | 59.41 ± 12.1 |
| Median (25th–75th percentile) | | 60 (52–68) |
| Range | | 23–84 |

**Table 2: Incidence of Pneumothorax Among Study Subjects**

| Pneumothorax | Frequency | Percentage |
|---|---|---|
| Present | 106 | 21.2% |
| Absent | 394 | 78.8% |
| Total | 500 | 100% |

**Table 3: Association Between Pneumothorax and Age Group**

| Age Group (years) | Pneumothorax Present | Pneumothorax Absent | Total | p-value |
|---|---|---|---|---|
| ≤60 | 49 | 204 | 253 | |
| >60 | 57 | 190 | 247 | 0.391 |
| Total | 106 | 394 | 500 | |

**Table 4: Association Between Pneumothorax and Lesion Depth from Pleural Surface**

| Depth from Pleura (cm) | Pneumothorax Present | Pneumothorax Absent | Total | p-value |
|---|---|---|---|---|
| ≤1.5 | 24 | 210 | 234 | |
| >1.5 | 82 | 184 | 266 | 0.001** |
| Total | 106 | 394 | 500 | |

**Table 5: Association Between Pneumothorax and Number of Needle Passes**

| Number of Needle Passes | Pneumothorax Present | Pneumothorax Absent | Total | p-value |
|---|---|---|---|---|
| 1 | 13 | 191 | 204 | |
| 2 | 22 | 113 | 135 | |
| ≥3 | 71 | 90 | 161 | 0.001** |
| Total | 106 | 394 | 500 | |

## 4. DISCUSSION

The incidence of pneumothorax following CT-guided transthoracic lung biopsy in our study was found to be 21.2%, which aligns closely with recent international data suggesting a prevalence ranging from 15% to 25% in similar procedures [11]. The development of pneumothorax is multifactorial, but lesion depth, number of needles passes, and patient-specific factors remain the predominant contributors. In our analysis, the depth of the lesion was significantly associated with the risk of pneumothorax. This corroborates the findings of Yamagami et al., who noted a substantially higher risk for lesions located deeper than 1.5 cm from the pleural surface [12]. This likely reflects the increased lung parenchymal traversal, which elevates the chance of alveolar disruption and subsequent air leak into the pleural space.

Another important risk factor observed was the number of needle passes required to obtain a satisfactory specimen. In our study, patients who underwent more than two passes had a significantly increased risk of developing pneumothorax, consistent with the work by Leung et al., who demonstrated a proportional increase in complication rate with increased manipulation [13]. The technical difficulty often necessitating multiple attempts is more common in smaller or cavitating lesions, further compounding the risk.

Although age and sex were evaluated as potential contributing factors, our findings showed no statistically significant correlation between these demographics and pneumothorax incidence. This contrasts slightly with the study by Sheth et al., where older patients were found to have a modestly higher risk, potentially due to increased lung frailty and reduced elastic recoil [14]. However, discrepancies could be due to differences in population characteristics and lung pathology distribution.

Management-wise, most cases of pneumothorax in our cohort were minor and required conservative treatment only. The risk of developing a tension pneumothorax or requiring tube thoracostomy remains low but necessitates clinical vigilance, particularly in high-risk patients. A study by Ko et al. emphasized the importance of real-time patient monitoring and protocolized post-biopsy observation to mitigate severe outcomes [15]. These findings highlight the necessity of individualized risk stratification before conducting lung biopsies and the potential for tailored procedural modifications, such as positioning strategies, coaxial techniques, or the use of smaller gauge needles, in selected high-risk patients.

## 5. CONCLUSION

Pneumothorax remains a frequent complication of CT-guided transthoracic lung biopsy, occurring in approximately one-fifth of patients. Lesion depth and the number of needle passes emerged as statistically significant risk factors. Identifying and minimizing modifiable risk elements—such as reducing needle passes and being cautious with deeper lesions—can significantly enhance procedural safety. Future studies may focus on predictive risk scoring models to individualize procedural planning and improve patient outcomes

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