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# Effectiveness of normal saline instillation in sealing the biopsy tract to reduce complications of CT-guided transthoracic lung biopsy: A hospital-based interventional study

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## Abstract

**Background:** Computed tomography (CT)-guided transthoracic lung biopsy is a crucial diagnostic procedure for pulmonary lesions, but it is associated with complications, most notably pneumothorax. This study aimed to evaluate the effectiveness of sealing the biopsy tract with sterile normal saline to reduce iatrogenic complications.

**Methods:** This longitudinal, hospital-based interventional study included 84 patients with lung masses (≥3 cm) undergoing CT-guided core biopsy. Patients were alternately assigned to two groups: Group A (n=42), where the biopsy tract was sealed with 4 mL of sterile 0.9% normal saline post-procedure, and Group B (n=42), where no sealant was used (control). The primary outcome was the incidence of pneumothorax. Secondary outcomes included rates of chest tube insertion and other complications.

**Results:** The overall incidence of pneumothorax was 22.61% (19/84). The incidence of pneumothorax was significantly lower in the saline sealing group (Group A) compared to the control group (Group B) (6% vs. 16%; p=0.0352). Chest tube insertion was required in 1 patient (2.4%) in Group A and 3 patients (7.1%) in Group B, though this difference was not statistically significant. The intervention also significantly reduced pneumothorax incidence in high-risk subgroups, including patients with smaller lesions (3-5 cm), emphysema, and a history of smoking. There was no significant difference in the incidence of post-procedural haemoptysis between the groups.

**Conclusion:** Sealing the biopsy tract with normal saline is a safe, inexpensive, and effective technique that significantly reduces the incidence of iatrogenic pneumothorax following CT-guided transthoracic lung biopsy, particularly in high-risk patients. This simple manoeuvre should be considered for routine clinical practice.

**Keywords:** Transthoracic Lung Biopsy; Normal Saline; Pneumothorax; Iatrogenic Complications; Ct-Guided Biopsy; Tract Sealing

## 1. Introduction

Lung cancer remains one of the foremost causes of cancer-related mortality globally and in India, where it is the most common cancer in males [1]. The accurate and timely diagnosis of suspicious pulmonary lesions is paramount for effective treatment planning. Computed tomography (CT)-guided transthoracic lung biopsy (TTLB) has become an indispensable tool in this diagnostic pathway, offering high diagnostic accuracy, especially for peripheral lung lesions, with yields often surpassing those of transbronchial or ultrasound-guided methods [2].

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Despite its diagnostic utility, TTLB is an invasive procedure associated with a significant risk of complications. Pneumothorax is the most frequent complication, with reported incidence rates varying widely from 9% to 54%, with an average of approximately 20% [3]. While many cases of pneumothorax are small and self-limiting, a notable fraction (0.5-7.5%) require chest tube insertion for management, leading to increased patient morbidity, prolonged hospitalization, and higher healthcare costs [3]. Other potential complications include pulmonary haemorrhage, haemoptysis, and, rarely, systemic air embolism [2].

Given these risks, considerable research has focused on developing techniques to minimize post-biopsy complications. These strategies can be broadly categorized into positional manoeuvres and the injection of sealants into the biopsy tract. Positional precautions, such as placing the patient puncture-site-down post-procedure, aim to use gravity to facilitate sealing of the pleural tear [4]. The second approach involves the direct application of a sealant to occlude the needle tract. A variety of materials have been investigated, including autologous blood clots, gelatin sponges (Gelfoam), fibrin glue, and other proprietary hydrogel plugs [5]. While these agents have shown variable efficacy, their use can be limited by factors such as cost, availability, the need for special preparation, and potential for adverse reactions.

Normal saline (0.9% NaCl) presents an attractive alternative sealant. It is universally available in clinical settings, inexpensive, requires no preparation, and is biologically inert, posing no known risk of adverse tissue reactions. The underlying principle is that instilling an inert fluid into the tract creates a liquid seal over the visceral pleural puncture site, preventing air from leaking from the lung parenchyma into the pleural space. This study was designed to prospectively evaluate the efficacy and safety of this simple technique.

The primary objective of this study was to determine whether sealing the biopsy tract with sterile normal saline after CT-guided tru cut lung biopsy can prevent or reduce the incidence of iatrogenic pneumothorax. Secondary objectives included assessing the overall incidence of post-procedural complications and evaluating the effectiveness of this intervention specifically in patient subgroups considered to be at high risk for pneumothorax.

## 2. Materials and Methods

### 2.1. Study Design and Population

This was a longitudinal, hospital-based interventional study conducted at the Department of Respiratory Medicine, N.R.S Medical College & Hospital, Kolkata, between July 2023 and December 2024. The study received approval from the institutional ethical and scientific committees.

The study population consisted of patients admitted with a visible lung mass (≥3 cm in greatest diameter) on CT thorax. Patients were included if they were scheduled for a CT-guided transthoracic biopsy. Exclusion criteria were: presence of large bullae, cystic lesions, contralateral pneumonectomy, diffuse parenchymal lung disease, mediastinal masses, pre-existing pneumothorax, lesions suspected of being vascular, hemodynamic instability, uncorrected coagulopathies, pregnancy, or refusal to provide consent.

### 2.2. Sample Size and Allocation

The sample size was calculated based on a superiority design, using data from a previous study by Billich *et al.* [6], which reported a pneumothorax incidence of 34% in a control group and 8% in a saline-sealing group. With a significance level (α) of 0.05 and a power (1-β) of 80%, the calculated sample size was 42 patients per group.

A total of 120 patients were screened, and 84 were enrolled after applying exclusion criteria. Enrolled patients were alternately allocated into two groups: Group A (Intervention) and Group B (Control).

### 2.3. Procedure

All procedures were performed by a postgraduate trainee under the supervision of an attending consultant. Written informed consent was obtained from all participants after a detailed explanation of the procedure and associated risks.

Patients were positioned prone, supine, or in lateral decubitus based on the location of the lesion to ensure the shortest and safest access route. A non-contrast CT scan was performed to localize the lesion and plan the needle trajectory, avoiding fissures, large vessels, and bullae. The puncture site was anesthetized with approximately 3 mL of 2% lignocaine.

A standard coaxial technique was employed using a 16-gauge coaxial introducer needle and a compatible 16-gauge automatic core biopsy gun with a 2.2 cm penetration depth. The coaxial needle was advanced under CT guidance to the edge of the lesion. After removing the inner stylet, four core biopsy samples were obtained using the biopsy gun. Patients were instructed to hold their breath during pleural transgression and to breathe calmly otherwise.

- **In Group A (Intervention):** After the final biopsy sample was taken, 4 mL of sterile 0.9% normal saline was slowly injected through the coaxial sheath as it was withdrawn in a single, swift motion.
- **In Group B (Control):** The coaxial sheath was removed in a single, swift motion without any injection.

Immediately after needle withdrawal, a sterile dressing was applied, and all patients were rolled into a puncture-site-down position. They were instructed to remain in this position for two hours, minimizing talking, coughing, or straining.

### 2.4. Outcome Assessment and Data Collection

A post-procedure CT scan was performed immediately to detect pneumothorax. The size of the pneumothorax was graded as mild (<2 cm), moderate (2-4 cm), or severe (>4 cm) based on the maximum distance between the lung surface and the chest wall. An intercostal chest drain was placed for severe pneumothorax or if the patient became symptomatic. A follow-up chest X-ray was performed after 4 hours. Patient demographics, lesion characteristics (size, location), and procedural details were recorded.

### 2.5. Statistical Analysis

Data were analysed using GraphPad Prism 9.0 software. Continuous variables were compared using appropriate tests, and categorical variables were compared using Fischer's exact test or the Chi-square test. A *p*-value of <0.05 was considered statistically significant.

## 3. Results and Analysis

### 3.1. Baseline Characteristics

A total of 84 patients were included in the final analysis, with 42 in the saline plugging group (Group A) and 42 in the control group (Group B). The baseline demographic and lesion characteristics of the two groups are summarized in Table 1. The mean age in Group A was significantly lower than in Group B (58.1 vs. 63.1 years, p=0.031). There were no other statistically significant differences between the groups in terms of gender, lesion size, presence of emphysema, lesion location, or patient positioning during the procedure.

**Table 1** Comparison of baseline parameters between two groups

| Parameter | Group A (NS plugging) (n=42) | Group B (No NS plugging) (n=42) | *p*-value |
|---|---|---|---|
| Age (Mean±SD) | 58.11±10.4 | 63.14±7.6 | 0.031* |
| Gender (Male/Female) | 35 (83%) / 7 (17%) | 36 (85%) / 6 (15%) | 1.0 |
| Lesion Size (cm) | | | |
| 3-5 | 18 (42%) | 18 (42%) | 0.52 |
| 5-8 | 19 (45%) | 18 (42%) | |
| >8 | 5 (12%) | 6 (14%) | |
| Presence of Emphysema | 14 (33%) | 15 (35%) | 0.8 |
| Location of Lesion | | | |
| Upper Lobe | 20 (47%) | 24 (57%) | 0.49 |
| Middle Lobe | 3 (7%) | 3 (7%) | |
| Lower Lobe | 19 (47%) | 15 (35%) | |
| Biopsy Position | | | |

| | | | |
|---|---|---|---|
| Supine | 14 (33%) | 19 (45%) | 0.37 |
| Prone | 28 (66%) | 23 (55%) | |
| *statistically significant | | | |

### 3.2. Incidence of Pneumothorax and Other Complications

The overall incidence of pneumothorax across both groups was 22.61% (19 of 84 patients). As shown in Table 2, the incidence of pneumothorax was significantly lower in the saline sealing group (Group A) at 6% (5/42 patients) compared to 16% (14/42 patients) in the control group (Group B) (p=0.0352).

**Table 2** Incidence of Pneumothorax in both the groups

| **Parameter** | **Pneumothorax** | **No Pneumothorax** |
|---|---|---|
| Normal Saline Plugging | 5 (6%) | 37 |
| No Normal Saline Plugging | 14 (16%) | 28 |
| *p*-value | 0.0352* | |
| *statistically significant | | |

An intercostal drain was required for 1 patient in Group A (2.4% of the group, 20% of those with pneumothorax) and 3 patients in Group B (7.1% of the group, 21% of those with pneumothorax). This difference was not statistically significant ($p>0.05$).

The second most common complication was haemoptysis, which occurred in 5 patients overall (5.95%). It was observed in 3 patients in Group A and 2 patients in Group B, a non-significant difference ($p>0.05$).

### 3.3. Efficacy in High-Risk Subgroups

The analysis of high-risk subgroups revealed that saline instillation was particularly beneficial:

- **Lesion Size 3-5 cm:** Incidence of pneumothorax was significantly reduced ($p=0.0293$).
- **Smokpppners:** Incidence of pneumothorax was significantly reduced ($p=0.04$).
- **Emphysematous Lung:** Incidence of pneumothorax was significantly reduced ($p=0.037$).
- **Lesions >2 cm from Pleura:** No significant reduction in pneumothorax was observed ($p=0.66$).

## 4. Discussion

This prospective interventional study demonstrates that sealing the needle tract with a small volume of normal saline is a simple and effective manoeuvre to reduce the incidence of pneumothorax following CT-guided transthoracic lung biopsy. The overall pneumothorax rate in our study cohort was 22.61%, which is consistent with the rates of 9-54% reported in the existing literature [3]. Our key finding is that the intervention group experienced a significantly lower pneumothorax rate (6%) compared to the control group (16%), supporting the routine use of this technique.

Our findings are in alignment with several previous studies. Billich *et al*. [6] reported a similar reduction in pneumothorax incidence from 34% to 8% with saline sealing. Li *et al*. [3], in a randomized controlled trial, also found a significant decrease in both pneumothorax (26.1% to 6.2%) and chest tube placement rates with saline sealing. A retrospective study by Roman *et al*. [7] further corroborated these results, showing a pneumothorax rate of 20.7% with saline versus 35.1% without. In contrast, one study by Khorochkov *et al*. [8] found that saline injection reduced pneumothorax size and the need for chest tubes but did not significantly alter the overall incidence. The prospective and alternately allocated design of our study strengthens the evidence in favour of the intervention's efficacy in reducing the primary occurrence of pneumothorax.

The mechanism by which normal saline prevents pneumothorax is likely related to the creation of a fluid seal. The instilled saline fills the needle tract through the lung parenchyma and visceral pleura, physically blocking the pathway

for air to escape from the alveoli into the pleural space. This "water seal" principle is simple yet effective. Unlike other sealants like blood clots or gelatin foam, normal saline is inert, readily available, and does not induce a local tissue reaction or carry a risk of embolism [3,9]. Its ease of use and low cost make it a highly practical option for widespread adoption.

A crucial aspect of our study was the evaluation of the technique's effectiveness in patients with established risk factors for pneumothorax. We found a statistically significant benefit in patients with emphysema, a history of smoking, and smaller lesion sizes (3-5 cm). Patients with emphysema have reduced elastic recoil and fragile parenchymal tissue, making them more susceptible to persistent air leaks. The fact that saline sealing was effective in this vulnerable group is a clinically important finding. Similarly, smaller lesions often require more manipulation and have a longer intraparenchymal tract, increasing risk. The protective effect of saline in these cases underscores its utility.

While the incidence of pneumothorax was significantly reduced, the rate of chest tube placement did not reach statistical significance in our study (1 patient in the intervention group vs. 3 in the control group). This is likely attributable to the relatively small sample size and the overall low number of events (chest tube placements). However, a clear trend towards fewer interventions was observed. Larger studies or meta-analyses, such as the one by Huo *et al*. [10], have shown that saline tract sealant can lead to a ninefold reduction in chest drain insertion rates.

### 4.1. Limitations

This study has several limitations. First, it was conducted at a single institution, which may limit the generalizability of the findings. Second, although performed under expert supervision, the biopsies were conducted by different trainees, which could introduce inter-operator variability. Third, our study excluded lesions smaller than 3 cm, and the findings may not apply to biopsies of smaller nodules. Fourth, delayed pneumothorax occurring after the 4-hours of observation period was not captured. Finally, the amount of normal saline used was fixed at 4 mL and was not adjusted based on lesion size or depth, which could be an area for future optimization.

## 5. Conclusion

Sealing the biopsy tract with 4 mL of sterile normal saline is a safe, simple, and cost-effective method that significantly reduces the incidence of iatrogenic pneumothorax following CT-guided transthoracic lung biopsy. The benefit is particularly pronounced in patients with high-risk features such as emphysema and smaller lesions. Given its ease of implementation and lack of adverse effects, this technique should be routinely incorporated into clinical practice to enhance patient safety during this common diagnostic procedure. Further multicentre, randomized controlled trials with larger sample sizes are warranted to confirm these findings and to explore its effect on chest tube insertion rates more definitively.

## Compliance with ethical standards

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### *Disclosure of conflict of interest*

The authors declare that there is no conflict of interest.

### *Statement of ethical approval*

This study was approved by the Institutional Ethics Committee of N.R.S Medical College & Hospital. All procedures performed 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.

### *Statement of informed consent*

Informed consent was obtained from all individual participants included in the study.

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