Efficacy of Normal Saline for Sealing the Needle Tract to Reduce Pneumothorax Incidence after Transthoracic Needle Lung Biopsies

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Received 28/11/2023 Revised 22/01/2024 Accepted 26/03/2024

Abstract

Background: Pneumothorax is a frequent complication of transthoracic needle biopsy (TTNB) procedures, often necessitating chest tube placement and hospitalization. The demand for lung biopsies is increasing due to the rising incidence of lung cancer and the identification of asymptomatic lung nodules, escalating the economic burden associated with complex lung biopsy procedures. Various techniques have been explored to reduce pneumothorax incidences in TTNB, including rapid rollover, autologous blood patch, fibrin gel plug, and normal saline sealant. However, there is no consensus on the most effective method.

Objective: The study evaluates the benefit of employing normal saline solution (NSS) tract embolization to reduce iatrogenic pneumothorax.

Material and method: This descriptive retrospective study was conducted at Vachira Phuket Hospital from January 2021 to September 2023. A total of 64 patients undergoing lung biopsies with and without NSS were compared. In the NSS group, 1-3 ml of normal saline was injected while withdrawing the coaxial sheath after the biopsy.

Result: Post-biopsy outcomes revealed a slight reduction in pneumothorax rates in the NSS group (18.8%, 6/32 patients) compared to the control group (31.2%, 10/32 patients), but this difference was not statistically significant (P=0.693). The need for pneumothorax chest drain (PCD) placement was marginally lower in the NSS group (3.1%, 1/32 patients) than in the control group (9.4%, 3/32 patients), indicating chest tube insertion in cases of severe pneumothorax (more than 4 cm in CXR measurement) or if the patient developed dyspnea. However, this difference did not reach statistical significance (P=0.613).

Conclusion: While the NSS group exhibited a trend towards lower pneumothorax rates and decreased chest tube insertions post-biopsy, these differences did not reach statistical significance. Further research with larger sample sizes and refined methodologies, such as randomized controlled trials, is warranted to elucidate the role of NSS in TTNB procedures.

Keywords: Lung Biopsy, TTNB, Transthoracic Needle Biopsy, Pneumothorax, Normal Saline Tract Embolization

Introduction

Pneumothorax is the most common complication of transthoracic needle biopsy (TTNB), with reported incidences ranging from 12% to 45% and chest tube placement necessary in 2% to 15% of cases [1] [2]. With the increasing rate of lung cancer and the high detection rate of asymptomatic lung nodules, the demand for lung biopsies is growing, thereby heightening the economic burden of complicated lung

biopsy procedures[3]. This has led to a significant need for hospitalization to manage symptoms such as chest pain, shortness of breath, and hypoxia [4]. Consequently, there is a strong interest in reducing iatrogenic pneumothorax to decrease the rates of chest tube placement and hospitalization. Various techniques have been explored to reduce pneumothorax incidences in TTNB [5], including rapid rollover [6], autologous blood patch [7] [8], fribrogel plug [9] [10], and normal saline sealant [11] [12]. However, there is no consensus on the most effective method. Normal saline is not prone to adverse reactions, is inexpensive, and is easy to use. Billich et al. [11] initially reported that the instillation of saline solution into the needle tract could reduce the incidence of pneumothorax. In 2013, Li et al. [12] confirmed that normal saline significantly reduces the incidence of pneumothorax and subsequent chest tube placement after CCT-guided transthoracic needle biopsy. However, there is limited data available, with only two small series mentioning saline tract sealing to prevent pneumothorax, and the results were dependent on a limited number of patients and variable experience.

Since 2020, our institution has routinely performed transthoracic needle biopsy (TTNB) procedures. During this time, we noticed a gradual increase in the incidence of pneumothorax, attributed to the rising number of cases and the complexity of the disease or cases. This increase is partly due to the need for pathology not only for diagnosis but also for guiding chemotherapy or targeted therapy without an effective protective method to mitigate this risk. In 2022, we implemented normal saline solution (NSS) tract embolization as a novel approach to reduce the occurrence of pneumothorax. This strategy aimed not only at lowering the rate of pneumothorax but also at reducing the necessity for additional radiographs, which would decrease the cumulative radiation dose, extend observation durations of PCD insertion, and, in some cases, reduce the need for hospital admissions. Based on these observations, we hypothesized that employing a saline sealing tract following a lung biopsy could reduce the incidences of pneumothorax and chest tube insertions, especially when compared to TTNB outcomes from 2021-2022, where normal saline sealing was not applied.

Material and method

Objective

1. To evaluate the incidence of pneumothorax after using normal saline sealing the needle track after TTNB, compared with without using normal saline sealing.

2. To evaluate the incidence of chest tube placement after using normal saline sealing the needle track after TTNB, compared with without using normal saline sealing.

Patients

This descriptive retrospective study was conducted at Vachira Phuket Hospital during January 2021 and September 2023. A total of 64 patients undergoing lung biopsies with and without NSS were compared. The study included patients who were 18 years or older with lung lesions of undetermined cause and who underwent a biopsy guided by cone-beam computed tomography (CBCT). Patients with lung lesions smaller than 10 mm in diameter or lesions suspected to be of vascular origin were excluded

from the study. The study protocol was approved by the Human Research Ethics Committee of Vachira Phuket Hospital (VPH REC 022/2023).

Variables analyzed about the occurrence of pneumothorax included patient-dependent factors such as sex, age, and emphysematous grading on CBCT. Lesion factors included lesion characteristics, lesion size, lesion-pleural distance, lesion location, and needle-pleural angle. Procedural factors encompassed patient position and needle-pleural angle. Lesion size was measured along the maximum long-axis diameter. The lesion-pleural distance was defined as the distance from the lesion to the pleural surface. The needle-pleural angle was the acute angle between the needle and the pleural surface.

Procedure

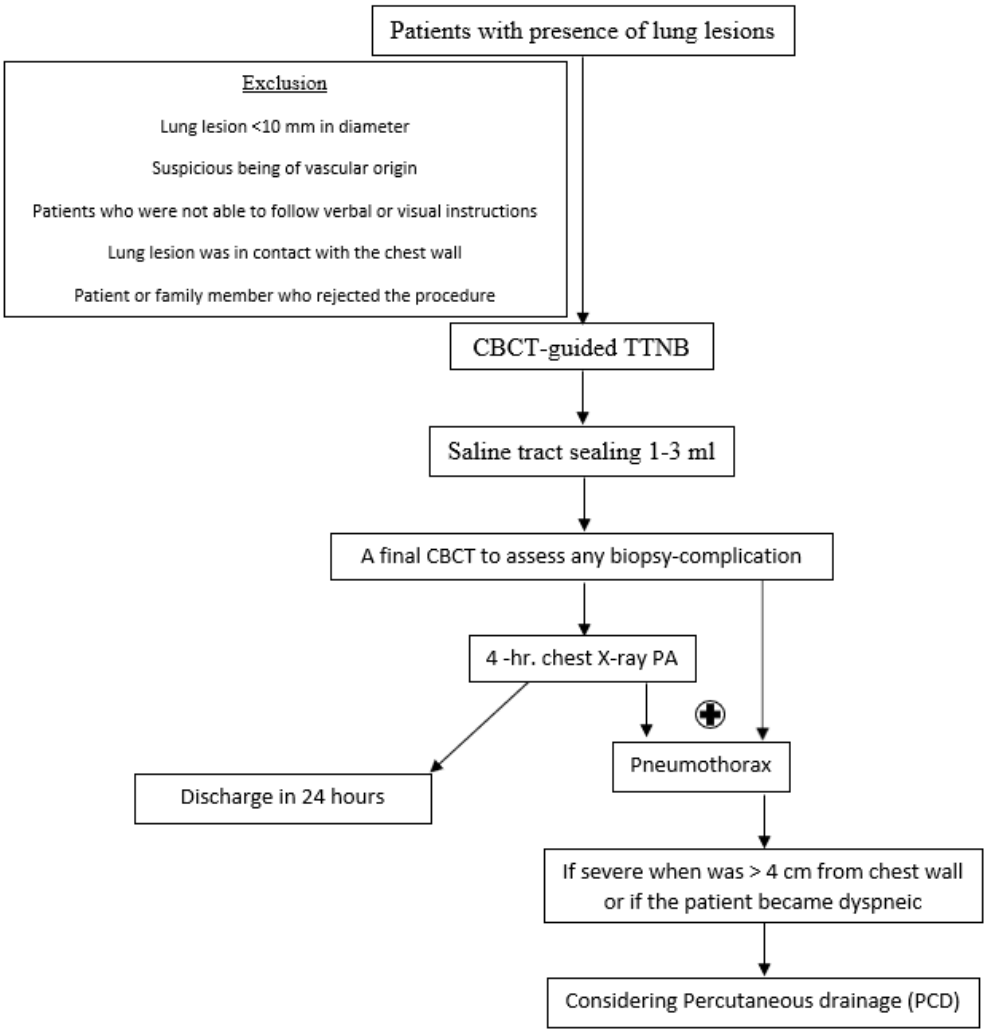
All procedures were carried out between January 2021 and September 2023 by two interventional radiologists with 3 and 6 years of experience in transthoracic needle biopsy (TTNB). Before the lung biopsy, Patients were positioned in supine, prone, or lateral decubitus positions to optimize access to the target lesion. A pre-procedural Cone-Beam Computed Tomography (CBCT) scan was conducted for biopsy planning, utilizing CBCT virtual navigation guidance software [13] in the angiography suite with an Alphenix Biplane angiography system (Canon, Tokyo, Japan). Each targeted lung nodule was designated as the target point, and the biopsy guidance software automatically depicted the needle tract leading to the target nodule. The distance between the skin and the pleura was measured. Following localized anesthesia (2% Xylocaine without adrenaline, 2-10 ml), a 19G co-axial introducer needle (Brad Biopsy, Tempe, Arizona, USA) was advanced into the thorax along the virtual pathway displayed on the real-time fluoroscopy monitor until it reached the target point. Subsequently, the biopsy was performed using a 20G semi-automated cutting needle (Brad Biopsy, Tempe, Arizona, USA) with a coaxial technique. Adequacy of the tissue sample may necessitate cutting in multiple angles.

After completion of the biopsy, the coaxial sheath was withdrawn in one swift motion without injection of normal saline in the control group from January 2021 to June 2022. In the normal saline used group from July 2022 to September 2023, 1-3 ml of normal saline was injected while the coaxial sheath was withdrawn (Figure 1). The speed of withdrawal was similar in the two groups.

Following the procedure, a final CBCT scan was conducted to evaluate any biopsy-related complications. All patients underwent a 4-hour observation period in the care units, after which a posteroanterior inspiration radiograph was performed. If symptoms appeared earlier, a radiograph was obtained promptly. The 4-hour post-procedural pneumothorax detected by CXR was categorized as mild when lung surface retraction was less than 2 cm, moderate when lung surface retraction measured between 2 to 4 cm and severe when lung surface retraction was greater than 4 cm from the chest wall. A chest tube was inserted in cases of severe pneumothorax or if the patient developed dyspnea.

Patients without clinical symptoms were discharged after 24 hours. In the presence of pneumothorax, serial inspiratory chest radiographs were acquired. Chest tubes were reconsidered for insertion if the estimated pneumothorax size was rapidly expanding and causing chest pain or shortness of breath symptoms.

Flow



Statistical Analysis

The data was analyzed using Microsoft Excel 365. Qualitative variables were presented as percentages and frequencies, while quantitative variables were analyzed using means and standard deviations (SD). The correlation between the control group and intervention group regarding the occurrence of pneumothorax incidence was conducted using t-tests. Statistical significance was indicated by a p-value below 0.05.

Result

In our comparison between control and normal saline solution (NSS) groups (table 1), each with 32 cases, we found no significant age difference but a distinct male predominance in the NSS group (P=0.01). Emphysema incidence on CT and lesion types were similar across groups. The NSS group showed a significant difference in the involved lung lobe distribution (P=0.001) and a shorter median axis measurement (P=0.04), These outcomes suggest that inherent differences in patient demographics and

lesion characteristics may indeed influence procedural results. The observed differential, particularly in gender distribution and specific lobe involvement, underscores the necessity for a deeper investigation into how such variables affect the outcomes of NSS application in transthoracic needle biopsy (TTNB) procedures.

In assessing post-biopsy outcomes (table 2) between a control group and a group where normal saline solution (NSS) was used (each consisting of 32 cases), follow-up showed minimal differences in both follow-up duration (16.2 hours for control vs. 15.9 hours for NSS, P=0.456). The pneumothorax rates, with a slight reduction in the NSS group 6/32 (18.8%) vs. 10/32 (31.2%) but no significant difference (P=0.693). The requirement for a pneumothorax chest drain (PCD) was marginally lower in the NSS group 1/32 (3.1%) compared to the control group 3/32 (9.4%), yet this difference was not statistically significant (P=0.613). These findings indicate that NSS application in these procedures does not significantly alter the occurrence of pneumothorax or the need for PCD placement post-biopsy.

Our multivariate analysis (table 3) revealed the impact of Normal Saline Solution (NSS) usage during transthoracic needle biopsy procedures on pneumothorax incidence. Though the adjusted odds ratio indicated a reduction in pneumothorax events associated with NSS use (adj. OR = 0.3; 95% CI: 0.05, 1.68; P = 0.162), this association did not achieve conventional levels of statistical significance. It is noteworthy, however, that this trend suggests a promising direction for NSS in mitigating pneumothorax risk.

Discussion

CT-guided percutaneous core needle biopsy has emerged as an effective tool for distinguishing between benign and malignant pulmonary lesions, gaining broad acceptance due to its high diagnostic accuracy and minimal complication rates. Pneumothorax stands out as the most prevalent complication following percutaneous lung biopsy, frequently necessitating chest tube insertion and subsequent hospitalization. In our study, pneumothorax was observed in 25.0% of the biopsy procedures, with 6.25% of these cases requiring chest tube insertion for management. We found male gender to significantly predict the occurrence of pneumothorax, a finding that does not coincide with results from previous studies[5] [11] [14] [15] [16], which showed lesion size, needle-pleural angle, lesion-pleural distance, and emphysema were risk factors of pneumothorax, may indeed be attributed to constraints within our study, such as limited sample size or potential biases.

Given the results observed in the study, the discussion revolves around the application of normal saline solution (NSS) during transthoracic needle biopsy (TTNB) procedures and its impact on post-biopsy pneumothorax and the necessity for pneumothorax chest drain (PCD) placement. Despite previous literature suggesting potential benefits of NSS in reducing pneumothorax incidences, such as the studies by Billich et al. [11] and Li et al. [12], The outcomes of our study show that the modestly reduced instances of pneumothorax and the lesser necessity for pneumothorax chest drain (PCD) placements in the Normal Saline Solution (NSS) group did not achieve statistical significance. However, the trend observed hints at a potentially beneficial impact of NSS in lowering pneumothorax risk. The present study

enrolled 64 patients, while that of Billich et al. [11] and Li et al. [12] enrolled 140 and 323 patients, respectively. Both previous studies were randomized control trials and prospective control trials. This insight paves the way for future investigations, emphasizing the need for studies with larger sample sizes and refined methodologies to minimize bias. The current study has several limitations. Evaluating an individual radiologist's skill in lung biopsy, with or without normal saline for sealing the needle track, based on expertise level, presents challenges. Additionally, there may be variations in needle path selection among radiologists for a specific lesion, which can impact the variables chosen for statistical analysis. Another limitation could be the use of different volumes of normal saline for sealing the needle track. The final limitation is the small sample size in this study. While there is an observed trend toward reduced pneumothorax rates, this decrease does not reach statistical significance.

Conclusion

The study evaluated the effectiveness of using normal saline solution (NSS) during transthoracic needle biopsy (TTNB) to reduce pneumothorax incidents and the need for chest drain placement. Findings from comparing a control group and an NSS group of 32 cases each showed no significant differences in pneumothorax rates or chest drain requirements post-biopsy. While the NSS group exhibited slight reductions in these outcomes, the results lacked statistical significance. Further research with larger sample sizes is necessary. Implementing randomized controlled trials (RCTs) with blinding, using standardized protocols, and ensuring balanced groups through stratification or matching are essential control measures. Additionally, employing multivariate analysis to adjust for potential confounders and calculating an adequate sample size based on power calculations will enhance the reliability and validity of the study outcomes.

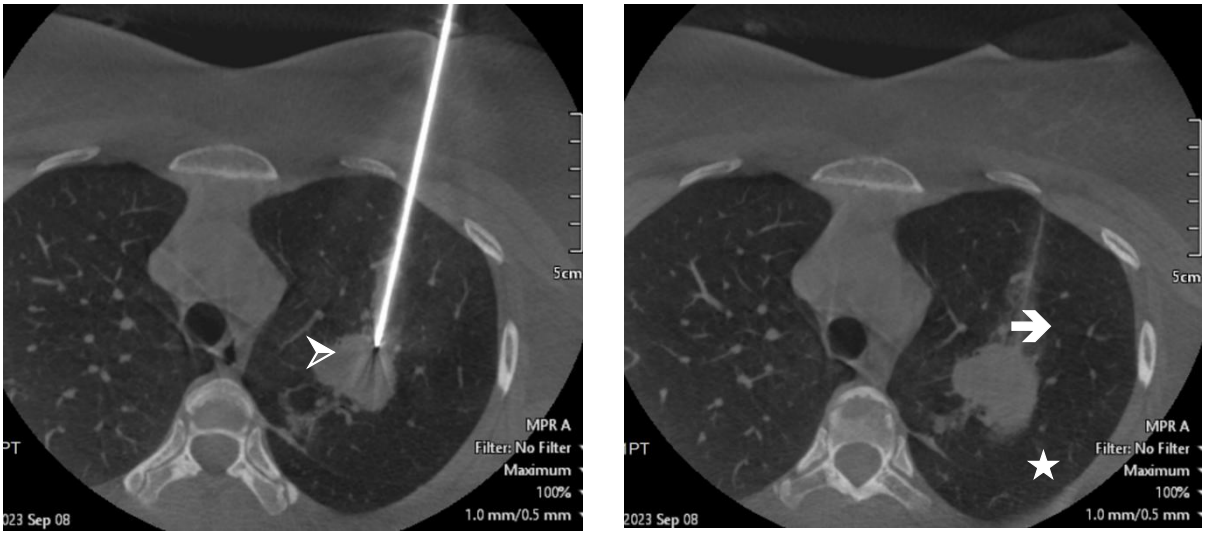


Figure 1 A-37-year-old-male with lung mass (Star) in the left upper lobe was requested for tissue biopsy. (a) The coaxial needle (Arrow Head) was inserted under CBCT guidance into the lesion. (b) CBCT performed after removing the coaxial sheath demonstrated the needle track filled to the lung parenchyma with 1 ml normal saline (Arrow). No pneumothorax was

Table 1 Baseline characteristics of the two groups.

Total	Control (32 cases)	NSS used (32 cases)	P value
Age (Mean+/-SD)	58.9 (15.3%)	61.8 (14.9%)	0.44
Male/Female	14/18	25/7	0.01
Emphysema on CT	7 (21.8%)	18 (56.3%)	0.052
Lesion characteristic			
Solid	28 (87.5%)	28 (87.5%)	1
Part-Solid	3 (9.4%)	4 (12.5%)	
Ground-glass opacities	1 (3.1%)	0 (0)	
Axis (Median+/-IQR)	85 (80,90)	80 (60,90)	0.04
Size (Median+/-IQR)	3 (2.1,4)	2.5 (1.6,3.5)	0.25
Distance (Median+/-IQR)	1.7 (1,2.2)	1.6 (1,2.2)	1
Lobe			
RUL	11 (34.4%)	6 (18.8%)	0.001
RML	2 (6.2%)	5 (15.6%)	
RLL	12 (37.5%)	2 (6.2%)	
LUL	6 (18.8%)	11 (34.4%)	
LLL	1 (3.1%)	8 (25%)	
Position			
Supine	17 (53.1%)	20 (62.5%)	0.453
Lateral	2 (6.2%)	0 (0)	

Total	Control (32 cases)	NSS used (32 cases)	P value
Prone	13 (40.6%)	12 (37.5%)	

Table 2 Outcome comparison in the two groups.

Total	Control (32 cases)	NSS used (32 cases)	P value
Follow time (Hours)	16.2 (2.5,19.7)	15.9 (5,17.5)	0.456
Post-biopsy Pneumothorax			
None	22 (68.8%)	26 (81.2%)	0.693
All grade	10 (31.2%)	6 (18.8%)	
Grade I	4 (12.5%)	3 (9.4%)	
Grade II	2 (6.2%)	1 (3.1%)	
Grade III	4 (12.5%)	2 (6.2%)	
PCD	3 (9.4%)	1 (3.1%)	0.613

Table 3 Our multivariate analysis in the two groups.

Multivariate analysis	crude OR (95%CI)	adj. OR (95%CI)	P (Wald's test)
Normal saline used vs control	0.51 (0.16,1.62)	0.3 (0.05,1.68)	0.171
Age	0.96 (0.93,1)	0.93 (0.87,0.99)	0.018
Male vs female	1.3 (0.41,4.08)	2.09 (0.25,17.63)	0.498
Emphysematous grading			
None	Reference	1	
Grade I	1.11 (0.1,12.04)	2.91 (0.12,68.15)	0.506
Grade II	1.67 (0.13,20.58)	3.1 (0.1,93.49)	0.516
Grade III	1.11 (0.25,5)	3.79 (0.27,53.08)	0.322
Grade V	1.67 (0.26,10.64)	3.43 (0.2,58.97)	0.396
Axis (cont. var.)	1.03 (0.99,1.08)	1.02 (0.97,1.07)	0.428
Size (cont. var.)	1.37 (0.94,2.01)	1.49 (0.83,2.67)	0.185
Lobe (Reference = RUL)			
RUL	Reference	1	
RML	0.57 (0.09,3.83)	2.82 (0.15,52.49)	0.486
RLL	0.11 (0.01,1.04)	0.07 (0,1.01)	0.051
LUL	0.31 (0.06,1.48)	0.54 (0.07,4.5)	0.57
LLL	0.71 (0.13,3.87)	2.38 (0.23,25.11)	0.471

Abbreviation

TTNB: Transthoracic Needle Biopsy

NSS: Normal Saline Solution

PCD: Pneumothorax Chest Drain

CBCT: Cone-Beam Computed Tomography

CXR: Chest X-ray

SD: Standard Deviation

OR: Odds Ratio

CI: Confidence Interval

CT: Computed Tomography

CCT: Cone-beam Computed Tomography

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