Predictive risk factors for pneumothorax following fluoroscopic-guided transbronchial lung biopsy

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ABSTRACT

Introduction: Fluoroscopic-guided transbronchial lung biopsy (FG-TBLB) is routinely performed via bronchoscopy to diagnose focal peripheral lesions and diffuse lung disease. Identifying the risk factors of FG-TBLB-related pneumothorax can assist the operator in taking pre-emptive measures to prepare for this potential complication.

Materials and Methods: We retrospectively analysed data from 157 patients who underwent FG-TBLB, with the primary outcome being procedure-related pneumothorax. We assessed several risk factors for pneumothorax following FG-TBLB: patient characteristics, location of biopsy, number of biopsies and computed tomography pattern. Univariate and multivariate logistic regression analyses were performed.

Results: One-hundred fifty-seven patients were included [mean (SD) age 57.9 (16.2) years; 60.5% male]. The most common location for FG-TBLB was the right upper lobe (n=45, 28.7%). The mean (SD) number of biopsy samples was 6.7 (2.1). Radiographic evidence of pneumothorax was reported in 12 (7.6%) patients, with 11 of those requiring intercostal chest tube intervention (mean air leak time: 5.7 days and 1 had persistent air leak requiring autologous blood patch pleurodesis. None experienced pneumothorax recurrence. Female gender and upper lobe location of the biopsy were identified as predisposing factors for pneumothorax. In the multivariable analysis, upper lobe biopsies were associated with a higher risk of pneumothorax (OR 0.120; 95% CI 0.015–0.963; p = 0.046).

Conclusion: The overall rate of pneumothorax is low. We recognise the increased risk of pneumothorax associated with upper lobe biopsy. These findings suggest that clinicians should exercise caution when performing FG-TBLB in this region and consider alternative biopsy locations whenever feasible. We suggest adequate planning and preparation should be implemented to minimise the risk of pneumothorax following FG-TBLB.

KEYWORDS:
Pneumothorax; transbronchial lung biopsy; bronchoscopy; fluoroscopy; diffuse lung disease

INTRODUCTION

Fluoroscopic-guided transbronchial lung biopsy (FG-TBLB) is a commonly used diagnostic procedure for evaluating pulmonary nodules and parenchymal lung diseases. While it is a minimally invasive procedure with a relatively low risk of complications, pneumothorax remains a recognised and potentially serious complication.[1] The incidence of pneumothorax following FG-TBLB varies widely across studies,[1] and a better understanding of the risk factors associated with this complication is needed. This study aims to determine the rate of pneumothorax following FG-TBLB and identify any risk factors that may predispose patients to this complication.

MATERIALS AND METHODS

Study Population and Data Acquisition
This was a single-centre retrospective cohort study at a university teaching hospital. The study population included all adults aged 18 years or older who underwent FG-TBLB between January 1st, 2020 and December 31st, 2022, and their medical records were reviewed. We investigated the risk factors, management and intervention of pneumothorax following FG-TBLB.

Patient Preparation
In this study, all FG-TBLB procedures were performed with the patient in the supine position, under conscious sedation. Patients received moderate sedation with individualised doses of midazolam (ranging from 1 to 5 mg) and fentanyl (ranging from 25 to 100 mcg). Before bronchoscopy, local pharyngeal anesthaesia was administered with 2% lidocaine. Additionally, topical anaesthesia with 2% lidocaine solution was used to anesthetise the airways. These standardised sedation and anaesthesia protocols were implemented to ensure patient comfort and safety during the procedure.

Bronchoscopic Procedure
Informed written consent was obtained from all patients before bronchoscopy, and thin-section computed tomography (CT) thorax with 0.5-mm slice thickness was performed on all patients before the procedure. The bronchoscopists evaluated and discussed the CT images to identify the bronchus sign and target lesion. In this study, FG-

Table I: Characteristics of the study cohort

Variables	n = 157
Sex	
Male	95 (60.5%)
Female	62 (39.5%)
CT indication for biopsy	
Nodule or mass	65 (41.4%)
Diffuse lung disease	15 (9.6%)
Infiltrates of unknown aetiology	77 (49%)
Location of biopsy	
Upper lobes	77 (49%)
Middle lobes	23 (14.6%)
Lower lobes	57 (36.4%)
Number of biopsies obtained	
1-4	6 (3.8%)
>5 (more than 6)	151 (96.2%)
Histopathological findings	
Normal	26 (16.6%)
Non-specific inflammation	53 (33.8%)
Malignancy	40 (25.5%)
Granulomatous inflammation	30 (19.1%)
Interstitial lung disease pathology	5 (3.1%)
Others	3 (1.9%)

Table II: Comparative analysis between patients with and without pneumothorax

Variables	No pneumothorax (n =145)	Pneumothorax (n =12)	OR (95% CI)	p value
Sex				
Male	92 (63.4%)	3 (25%)	1	
Female	53 (36.6%)	9 (75%)	5.208 (1.350 – 20.081)	*0.017
CT indication for biopsy				
Nodule or mass	62 (42.8%)	3 (25%)	1	
Diffuse lung disease	15 (10.3%)	0 (0%)	INFINITE	0.999
Infiltrates of unknown aetiology	68 (46.9%)	9 (75%)	2.735 (0.708 – 10.564)	0.144
Location of biopsy				
Upper lobes	67 (46.2%)	10 (83.3%)	1	
Middle lobes	22 (15.2%)	1 (8.3%)	0.305 (0.037 – 2.515)	0.270
Lower lobes	56 (38.6%)	1 (8.3%)	0.120 (0.015 – 0.963)	*0.046
Number of biopsies obtained				
1-4	5 (3.4%)	1 (8.3%)	1	
>5	140 (96.6%)	11 (91.7%)	0.393 (0.042 – 3.665)	0.412
Histopathological findings				
Normal	25 (17.2%)	1 (8.3%)	1	
Inflammation	49 (33.8%)	4 (33.3%)	2.041 (0.216 – 19.24)	0.533
Malignancy	38 (26.2%)	2 (16.7%)	1.316 (0.113 – 15.293)	0.826
Granulomatous	27 (18.6%)	3 (25%)	2.778 (0.271 – 28.482)	0.390
Interstitial lung disease	4 (2.8%)	1 (8.3%)	6.25 (0.322 – 121.334)	0.226
Others	2 (1.4%)	1 (8.3%)	12.5 (0.55 – 284.12)	0.113

*$p < 0.05$

TBLB was performed by five bronchoscopists with varying years of clinical experience ranging from 2 to 20 years. The bronchoscopy procedure involved at least three bronchoscopists, including one operator, one assistant, and one who monitored the patient's general condition. A fiberoptic flexible bronchoscope (Pentax EB-1990i, Japan) was used, and TBLB was performed by passing the closed forceps peripherally to the desired location under fluoroscopic guidance. Before TBLB, adrenaline 5 ml (1:10000) was flushed into the pre-selected segmental bronchus. Blood pressure, heart rate, and oxygen saturation were monitored during the bronchoscopy to ensure patient safety.

Diagnosis and Management of Pneumothorax
Immediately and 4 hours after FG-TBLB, an upright portable chest x-ray was performed on all patients. The attending bronchoscopist carefully reviewed the post-procedure chest X-ray to identify cases of pneumothorax. When pneumothorax was diagnosed, the attending bronchoscopist made decisions regarding the need for intercostal chest tube insertion or conservative management based on the patient's symptoms and the severity of pneumothorax. Oxygen supplementation was administered to all patients with pneumothorax to maintain an oxygen saturation of >95%.

Statistical Analysis

We analyse the clinical factors related to pneumothorax, including gender, lesion location, number of biopsies, CT pattern, and histopathological diagnosis. Data were presented in mean (standard deviation [SD]) for normally distributed data and median (interquartile range [IQR]) for non-normally distributed data. Associations between the variables and the incidence of pneumothorax were first examined by univariate logistic regression and presented as odds ratios (ORs) and 95% confidence intervals (CIs). Multivariable logistic regression was performed to calculate OR with 95% CI for post-procedure pneumothorax. We used logistic regression to identify significant associations between these variables and pneumothorax.

RESULTS

Patient and Target Lesion Characteristics

A total of 157 patients who underwent FG-TBLB were included in the analysis. Demographics and procedure-related data are listed in Table I. The mean (SD) age was 57.9 (16.2) years, with 60.5% male. The most frequent indication was unknown pulmonary infiltrates (n = 77, 49%).

Twelve (7.6%) patients developed pneumothorax following FG-TBLB. Eleven (91.7%) required intercostal chest tube insertion with the mean (SD) 5.7 (6.2) days chest tube duration. One patient had a persistent air leak and required autologous blood patch pleurodesis. None of the patients experienced pneumothorax recurrence.

The mean (SD) number of biopsy samples was 6.7 (2.1). The most common location for FG-TBLB was the right upper lobe (n = 45, 28.7%), followed by the right lower lobe (n = 42, 26.8%), left upper lobe (n = 27, 17.2%), left lower lobe (n = 21, 13.4%), right middle lobe (n = 14, 8.9%) and lingula (n = 8, 5.1%).

The histopathological diagnoses were as follows: lung cancer or other malignancy (n = 40, 25.5%), granulomatous disease (n = 30, 19.1%), non-specific inflammation (n = 53, 33.8%), interstitial lung disease (n = 5, 3.1%; 3 organising pneumonia, 1 interstitial fibrosis, 1 pulmonary alveolar proteinosis) and others (n = 3, 1.9%; include 2 pulmonary hamartomas and 1 silicosis). This study's total diagnostic yield of FG-TBLB was 83.4% (n = 131).

Predictive Factors for Pneumothorax

In the univariate analysis, female gender and biopsy location were identified as independent predisposing factors for pneumothorax. However, in the multivariable analysis, a significantly higher risk of pneumothorax was observed for FG-TBLB obtained from the upper lobes (odds ratio [OR] 0.120; 95% confidence interval [CI] 0.015–0.963; p = 0.046). Table II presents a comparative evaluation between patient groups with and without radiological evidence of pneumothorax.

DISCUSSION

TBLB is a commonly utilised procedure for diagnosing diffuse infiltrative lung diseases, as well as pulmonary nodules or masses. In immunocompromised individuals presenting with pulmonary infiltrates of unknown origin, TBLB is considered valuable in establishing a microbiological or tissue diagnosis. Despite the usefulness of TBLB in diagnosing various lung diseases, it is essential to recognise that the procedure carries potential complications. Notably, a study has reported the incidence of pneumothorax (1–4%) associated with TBLB.[2]

Our study revealed an incidence of FG-TBLB-related pneumothorax at 7.6%, consistent with the data reported in the BTS guideline and COMET trial.[3,4] Our study establishes that the risk factors associated with FG-TBLB-related pneumothorax include lesions in the upper pulmonary lobes, consistent with findings reported in previous studies.[5-8] Specifically, Huang et al.[7] reported that out of 13 pneumothorax cases, 10 occurred after TBLB from the upper lobes, although this association was not statistically significant (OR 3.34, p = 0.149) due to the small number of pneumothorax cases.[7] The higher risk of TBLB-related pneumothorax involving the upper lobes may be due to the prominence of subpleural blebs in the upper lobes and the greater distention and reduced compliance of alveoli in this region, likely resulting from the pleural pressure gradient.[9] However, in contrast to our findings, Izbicki et al.[10] reported that none of the post-procedural pneumothorax resulted from an upper lobe TBLB.

The performance of bronchoscopy under sedation carries a risk of respiratory depression, which is further complicated by the development of pneumothorax and a subsequent reduction in arterial PO2 levels. Pneumothorax during TBLB is typically due to injury of the visceral pleura caused by biopsy forceps.[11] Sedation may mask pleural pain that indicates the onset of pneumothorax. Recent studies using advanced tools such as robotic bronchoscopy or endobronchial ultrasonography with a guide sheath have reported rates of pneumothorax at 3.7% and 3.2%, respectively, suggesting that complete prevention of pneumothorax may be challenging.[12,13] Therefore, early identification of procedure-related pneumothorax and the availability of an intercostal chest tube device on-site are crucial, as suggested by our study and others.

In previous studies, the optimal number of biopsies for optimal diagnostic yield was reported to be 4–10[14], and the BTS guidelines recommend using fluoroscopy during TBLB and obtaining at least 5 or 6 samples.[4] However, our study found no association between the number of biopsies and the risk of pneumothorax, which is consistent with the results reported by Herout et al.[6]

Computed tomography is widely used to diagnose and evaluate pulmonary diseases. The findings of CT are helpful in determining the optimal site for transbronchial lung biopsy (TBLB). Our study showed no association between the CT pattern of nodular, diffuse or infiltrate types and the risk of pneumothorax during TBLB. This finding is consistent with a recent study conducted by Herout et al. However, Bae et al. reported a higher risk of pneumothorax in nodular lesions. The difference in the results of our study and the study conducted by Bae et al. may be due to differences in patient populations, sample size or the specific techniques used for TBLB. Further studies are needed to determine the impact of CT pattern on the risk of pneumothorax during TBLB.[15]

One potential limitation of the present study pertains to its single-centre, retrospective design. Given the variability in bronchoscopy protocols, including differences in biopsy techniques, sedation practices and fluoroscopy usage across institutions, it is possible that the risk of procedure-related pneumothorax may differ in ways not captured by our data. Therefore, caution should be exercised when generalising our findings to other settings.

CONCLUSION

In conclusion, our study demonstrated that FG-TBLB from the upper pulmonary lobe is associated with the highest risk of pneumothorax. These findings suggest that clinicians should exercise caution when performing FG-TBLB in this region and consider alternative biopsy locations whenever feasible. Furthermore, given the potential for pneumothorax as a post-procedural complication, appropriate measures should be taken to ensure prompt detection and management of this event.

ACKNOWLEDGEMENTS

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