Pneumothorax and Intrapulmonary Hemorrhage in Computed Tomography-Guided Transthoracic Biopsy

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ABSTRACT

Objective: To study the frequency of pneumothorax and intrapulmonary haemorrhage in computed tomography (CT) guided transthoracic needle lung biopsy (NLB) and the factors that affect the development of these complications in Pakistan through a representative limited data obtained from a tertiary care centre.

Study Design: Cross-sectional study.

Place and Duration of Study: Armed Forces Institute of Radiology and Imaging, Rawalpindi, from Jan 2018 to Feb 2019.

Methodology: A total of 68 patients who underwent CT-guided transthoracic biopsy were evaluated for intra- and immediate (within 04 hours) post-procedural pneumothorax and pulmonary haemorrhage. The factors affecting the development of these complications were evaluated.

Results: Complications developed in 30 patients with the frequency of pneumothorax at 26.5 % and frequency of pulmonary haemorrhage at 19.1%. Significant risk factors for the development of pneumothorax were small lesions less than 2.5 cm in diameter (p-value <0.05), increased needle track path within the lung tissue of more than 21 mm (p-value = 0.05), and presence of emphysema in the surrounding lung tissue (p-value <0.05). In addition, smaller lesion size (p-value <0.05) and increased traversed lung parenchyma (p-value <0.05) were also significant factors in the development of intrapulmonary haemorrhage.

Conclusion: Significant risk factors for pneumothorax and intrapulmonary haemorrhage are smaller lesion size and length of puncture path. The presence of emphysema is related to the development of pneumothorax.

Keywords: Computed tomography guided, Intrapulmonary haemorrhage, Lung biopsy, Pneumothorax.

INTRODUCTION

Computed tomography (CT)-guided transthoracic needle lung biopsy is a widely accepted procedure for diagnosing pulmonary nodules and masses, specifically those that are difficult to reach by bronchoscopy.[1] Indications include obtaining tissue samples for identifying malignant lesions, staging cases of metastatic nodules, determining aetiology in suspected infections, and guiding management.[1] With the emergence of lung cancer screening,[2,3] the volume of referrals for CT-guided lung biopsy is expected to increase further.[3,4]

CT guided needle lung biopsy (CTNLB) is considered a relatively safe and reliable procedure,[5,6,7] with sensitivity and specificity reported up to 95% and 99-100%, respectively.[8] CTNLB has significantly reduced the need for diagnostic thoracotomy and diagnostic pulmonary resections.[8,9] Because it is a minimally invasive procedure, the incidence of severe complications and length of hospital stay is much less than open lung biopsy.[6,7] Pneumothorax and pulmonary haemorrhage are by far the most commonly reported

complications.[6,10] Multiple factors, including the morphological features of the lesion, operator technique, and patient comorbidities, affect the development of these complications.[8] Bleeding diathesis and anticoagulation therapy are considered the major contraindications to the procedure, while bullous disease in the lesion region, chronic obstructive pulmonary disease, pulmonary hypertension and contralateral pneumonectomy are relative contraindications.[8]

Numerous studies have been conducted in the related fields and the results obtained have been shared with stakeholders to incorporate the same in future diagnosis and prevention of these complications. Therefore, this study was undertaken to explore the complication rates and factors that affect the development of these complications in patients undergoing CT-guided transthoracic biopsy of pulmonary nodules in our setup.

METHODOLOGY

This cross-sectional study was conducted after approval from the ethical review board (IERB Approval Certificate Number: 0025). All patients who underwent CT-guided core needle biopsy of pul-

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monary nodules between January 2018 and February 2019 were included. A total of 68 patients were evaluated using the consecutive sampling method. The subjects were informed about the purpose of the biopsy procedure, and written consent was obtained before the biopsy as a standard of care.

Inclusion Criteria: The inclusion criteria for CT-guided biopsy were (a) cases referred to our department after a non-diagnostic bronchoscopy, (b) a suspicious lesion that was not feasible at bronchoscopic biopsy, (c) reporting of complications at the time of the procedure or during the post-procedural monitoring period, (d) adequate complication monitoring.

Exclusion Criteria: The exclusion criteria included severe pulmonary disease (e.g., advanced Chronic Obstructive Pulmonary Disease with bullous parenchymal changes, contralateral pneumonectomy), suspicion of vascular anomaly or hydatid cyst, Forced Expiratory Volume in one second (FEV1) <30%, known coagulopathy, platelet count <60000/mm^3, International normalized ratio (INR) >1.5, or pulmonary arterial hypertension. Chest wall and mediastinal lesions were also excluded from this study. However, the central position of the lesion was not an exclusion criterion.

The pre-procedure assessment included a recent (within the last 6 weeks) chest CT, required to determine the patient selection and biopsy approach. In addition, the bleeding profile, including platelet count and INR, was stabilized before the procedure, and any anticoagulants or thrombolytics were stopped for 5-7 days prior to biopsy.

Computed tomography scans (128 slice Siemens) were performed to localize the lesion and determine the optimum access. Patients were positioned in a supine, prone or lateral decubitus position based on the lesion location within the chest, ensuring the safest and shortest path to the lesion. Lesions were localized with contiguous scans of 5mm thickness with breath triggering (constant inspiration or expiration position). The insertion site was then marked; puncture angle, passage through lung parenchyma, and distance between skin and pleura were measured. The needle path was planned not to traverse the thoracic wall vessels, relatively larger pulmonary vessels, interlobular fissures, and any visible bronchi whenever possible. A biopsy needle was inserted under local anaesthesia (20cc 2% xylocaine) through a small skin incision at the planned puncture angle. The location of the lesion was confirmed with the patient in the same breathing

position as before, and the needle advanced to the lesion under CT guidance. Multiple-pass coaxial needle system was used in all patients. Two biopsy specimens were obtained to minimize the risk of specimen inadequacy.

All patients underwent post-intervention CT scans at the level of upper, middle and lower thoracic levels with one sequence through the biopsy plane to rule out possible pneumothorax or significant parenchymal haemorrhage. Patients were routinely observed for 4-6 hours post-procedure. If indicated, a PA chest radiograph was performed after 4 hours and after 24 hours.

The risk factors evaluated were (a) patient-related such as age, gender and smoking history; (b) lesion related, such as lesion size (axial transverse diameter), emphysema surrounding the lesion, and lesion localization into upper, middle and lower lung lobes; (c) technical factors such as puncture path (lung parenchyma traversed by the needle) and needle trajectory angle. The distance between skin and parietal pleura was not included in the measurement of the puncture path. The needle angle trajectory was measured as the smallest angle between a line along the needle and a line tangential to the pleura at the needle entry site.

Lesions were divided into three groups according to lesion size; group 1: 0–1.99cm; group 2: 2-4.99 cm; group 3: 5 cm and higher. The cases were also classified into three groups according to the traversed parenchymal distance (from pleural surface to the lesion); group 1: 0–0.1 mm; group 2: 0.1–20 mm; group 3: 21 mm and above.

Statistical Package for Social Sciences (SPSS) version 20.0 was used for the data analysis. Frequencies and percentages were described for qualitative variables, such as gender and smoking status. Mean and standard deviation were described for quantitative variables, such as the lesion size. Chi-squared test and independent-sample t-test were applied to compare any association in the frequency distribution of the procedural complications (pneumothorax and pulmonary haemorrhage) with the associated risk factors. Multivariate logistic regression was applied to evaluate variables with significant *p*-values. The *p*-value of ≤ 0.05 was considered significant.

RESULTS

A total of 68 patients were evaluated. The mean age of patients was 61.24±7.25 years (range 50-82 years), with 56 males and 12 females. 55 (81%) patients

reported a smoking history. The distribution of lung nodules was according to lesion sizes: 14 (20.6 %) in Group-1; 19 (27.9 %) in Group-2; and 35 (51.5 %) in Group-3. The distribution of cases according to the traversed parenchymal distance by biopsy needle was: 11 (16.2 %) in Group-1; 28 (41.2 %) in Group-2; and 29 (42.6 %) in Group-3.

Complications developed in 30 patients with pneumothorax in 18 (26.5%) and pulmonary haemorrhage in 13 (19.1 %) patients. Three of these cases developed both pneumothorax and parenchymal haemorrhage.

The relationship between different groups was evaluated based on lesion sizes, and the development of pneumothorax (Table-I) using the Pearson chi-square test revealed a statistically significant difference (p= 0.02). Similarly, when groups classified according to the traversed parenchymal distance (p=0.048) and presence of emphysema surrounding the lesion (p= <0.044) were evaluated in terms of occurrence of pneumothorax, statistically significant results were found (Table-I). The location of the lesion in the upper,

with the development of pneumothorax (Table-II) was statistically significant (p<0.05).

The mean age of the patients for those who developed pneumothorax and those who did not have pneumothorax was 61 years. The average needle trajectory angle was 72.9 in cases with a pneumothorax and 76.9° in those without pneumothorax. No statistically significant association was determined between the two groups.

The relationship between lesion sizes and development of parenchymal haemorrhage (Table-III) using the Pearson chi-square test showed a statistically significant difference between the groups based on lesion sizes and development of parenchymal haemorrhage (p<0.001). Likewise, a significant difference (p=0.003) was found between the three groups based on the traversed parenchymal distance by biopsy needle and the development of parenchymal haemorrhage. Further analysis using multivariate logistic regression revealed that the highest rate of bleeding correlated with lesion size less than 2 cm (OR=13.07; 95% CI=3.21-53.12), and traversed parenchymal

Table-I: Association of risk factors with the development of pneumothorax (n=68)

Variables		Pneumothorax		p-value	Odds Ratio	95 CI
		Yes	No			
		Frequency (%)	Frequency (%)		3.91	1.13 – 13.50
Lesion Size	Group 1	7 (50.0)	7 (50.0)	0.02		
	Group 2	8 (42.1)	11 (57.9)		2.84	0.90 – 8.92
	Group 3	3 (8.5)	32 (91.4)		0.11	0.03 – 0.44
Traversed parenchymal distance					0.24	0.03 – 1.99
	Group 1	1 (9.1)	10 (90.9)	0.048		
	Group 2	5 (17.9)	23 (82.1)		0.43	0.14 – 1.46
	Group 3	12 (41.4)	17 (58.6)		3.88	1.24 – 12.16
Emphysema	Yes	8 (44.4)	10 (55.6)	0.044	3.20	1.00 – 10.20
	No	40 (20.0)	40 (80.0)			

middle or lower lobe did not show a significant association (p=0.54) with the development of pneumothorax. Further analysis using multivariate logistic regression revealed that the highest rate of pneumothorax correlated with lesion size less than 2 cm (OR =3.91; 95% CI=1.13-13.50), traversed parenchymal distance of more than 2 cm (OR=3.88; 95% CI=1.24-12.16), and presence of emphysema (OR=3.20; 95% CI=1.00-10.20).

Development of pneumothorax was also plotted against the mean age, average lesion size; mean traversed the parenchymal distance, and average needle trajectory angle. The relationship between average lesion size and mean traversed parenchymal distance

distance of more than 2 cm (OR=11.31; 95% CI=2.26-56.47). The presence of emphysema, location of the lesion, puncture angle and age of the patient were insignificant factors in the development of intrapulmonary haemorrhage.

Table-II: Correlations between mean lesion size and mean traversed parenchymal distance with pneumothorax(n=68)

Variables	Pneumothorax	Frequency	Mean ± SD	p-value
Lesion Size (cm)	Yes	18	2.47±1.38	<0.001
	No	50	5.10±1.62	
Traversed parenchymal Distance (mm)	Yes	18	2.19±0.68	0.005
	No	50	1.42±1.05	

DISCUSSION

The most frequent complication reported with percutaneous transthoracic biopsy is pneumothorax,[10,11] with an incidence reported up to 61%.[11,12] This risk of pneumothorax is directly related to the presence of obstructive lung disease, the distance of the target nodule from the pleural surface, the number of needle passes and operator experience. In addition, it is inversely related to the size of the lesion.[13] Pneumothorax was the most frequently occurring complication in our study as well. It was detected in 18 out of 68

segments and the development of pneumothorax. This observation was in contrast to the studies by Noureldin et al.[10] and Chami et al.[18] which report a higher incidence of pneumothorax in basal lung lesions due to greater vulnerability of basal lesions to the effect of diaphragmatic movement.[10,18] Similarly, no association between post-CTNLB pneu-mothorax and some of the other previously reported risk factors such as older age group, smoking status, and pleural needle angle was found in our study.[16,18]

Table-III: Association of risk factors with parenchymal hemorrhage(n=68)

Variables		Parenchymal Hemorrhage		p-value	Odds Ratio	95% CI
		Yes	No			
Lesion Size		Frequency (Percentage)	Frequency (Percentage)	0.0001		
	Group 1	8 (57.1%)	6 (42.9%)		13.07	3.21 – 53.12
	Group 2	4 (21.1%)	15 (78.9%)		1.19	0.32 – 4.43
	Group 3	1 (2.8%)	34 (97.1%)		0.05	0.01 – 0.43
Traversed Parenchymal distance				0.003		
	Group 1	0	11 (100.0%)			
	Group 2	2 (7.7%)	26 (92.9%)		0.20	0.04 – 1.00
	Group 3	11 (37.9)	18 (62.1%)		11.31	2.26 – 56.47

(26.5 %) cases. All pneumothoraxes in our sample were mild (lung surface retraction of less than 2cm) and resolved spontaneously.

When evaluating the association between lesion size and development of pneumothorax, a significant difference was determined in these groups. In addition, the independent samples t-test revealed a significant relationship between pneumothorax and mean lesion size. Smaller lesion size was also noted as a significant risk factor for pneumothorax in a Chinese study by Yeow et al.[14] an Italian study by Rizzo et al.[15] and a Japanese study by Hiraki et al.[16] In contrast, Li et al.[13] reported no influence of lesion size on the rate of pneumothorax.

Our study revealed that the rate of pneumothorax was lower in the pleural-based lesion and increased with traversing of parenchyma. As suggested by Li et al. with a longer needle path, there is a greater chance of patients breathing during the procedure and thus a higher risk of injury to pleura and lung parenchyma.[13] A longer needle path from the pleural surface to the lesion was noted as an independent risk factor for pneumothorax by studies conducted in Egypt [10], China [14], and Japan [17].

Emphysema is another established significant risk factor of pneumothorax in the literature,[10,14,15] and the current results were in accordance with this observation. Our results revealed a statistically insignificant relationship between the localization of lesions in lung

Parenchymal haemorrhage is the second most common complication with an incidence of 8-30%,[8,10,14] with a higher incidence of haemorrhage associated with lesion size, increased length of intrapulmonary biopsy tract, and the number of pleural passes.[13,14,15] patients (19.1%) in our study developed parenchymal haemorrhage. Our results were comparable with the study by Li et al. in which the rate of bleeding was 17.8% [13] and relatively less frequent compared to the study by Filippo et al. which reported the rate to be 27%.[7] We found pulmonary haemorrhage signifi-cantly associated with lesion size and traversed the paren-chymal distance, which is consistent with the litera-ture. Small lesion size is one of the established risk factors of post-CTNLB complications, being liable to excessive manipulation of the biopsy needle and thus greater parenchymal injury as reported by Nour-eld et al.[10], Yeow et al.[14], an Italian study by Rizzo et al.[15]

Our study was performed at a single site that attracts patients across Pakistan. All CT measures were calculated prior to the procedures and assessed objectively to minimize potential bias. The limitations of the study included a relatively small number of cases and our policy to discharge clinically insignificant complications.

CONCLUSION

Among various options available for histological diagnosis of pulmonary nodules, CT-guided NLB is a relatively safe alternative to diagnostic thoracotomy and pulmonary resections. Our study concluded that the size of the lesion and the traversed parenchymal distance were important factors in the development of both complications: pneumothorax and intrapulmonary haemorrhage. Cognizance of these factors, anticipation of potential complications, and careful biopsy planning can significantly reduce post-procedural patient morbidity.

Conflict of Interest: None.

Authors' Contribution

AI:, SIZ:, AUS:, AAA:, RR:, AS: Conception, design, analysis and interpretation of data.

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