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Research Article

Pneumothorax as Complication of CT Guided Lung Biopsy: Frequency, Severity and Assessment of Risk Factors

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Abstract

Background: CT-guided lung biopsy is routinely performed minimally invasive procedure. Imaging findings in the lung can have a broad differential diagnosis; therefore, it is indicated for definitive determination of pulmonary nodules or masses. Post-biopsy complications are common with most of them manageable in daycare. As pneumothorax is the most common complication, frequency and severity of pneumothorax with assessment of risk factors and follow-up for resolution is necessary.

Methods: A prospective evaluation of 123 biopsies with automated coaxial biopsy of 18 gauge was done. Post-biopsy pneumothorax was evaluated for its incidence and resolution. The studied risk factors were; patient age, sex, lesion location, lesion size, shortest pleural lesion depth, traversed lung parenchymal distance, presence of emphysema, fissure penetration, needle thoracic wall angle, and lesion characteristics.

Results: Reported immediate post-procedural pneumothorax was 22% with 19% of mild, 4% of moderate and 2.4% of severe cases. 51.9% of cases showed resolution within 24 hours. The intervention was required in only 4.8% of biopsy cases. A significant p - value of pneumothorax with the nodule depth increased traversed lung parenchymal distance, acute needle angle, fissure puncture, and presence of emphysema was seen. Emphysema was an independent variable in pneumothorax in multivariate analysis.

Conclusion: Pneumothorax is an unamenable consequence of CT-guided lung biopsy and a cautious approach should be kept in view of the variables that are associated with it to reduce its incidence and severity in patients.

More Information

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Keywords: CT guided biopsy; Lung biopsy; Nodule; Pneumothorax; Post-intervention pneumothorax; Fissure puncture; Emphysema

Introduction

CT-guided biopsy is a widely performed procedure and a safe, effective, and minimally invasive method of obtaining a tissue diagnosis of a pulmonary lesion. The percutaneous CT-guided biopsy procedure has potential for complications but its usefulness in management is now almost necessary. However various studies have shown that complications vary greatly, with only very few of them requiring hospitalisation, therefore awareness of complications associated with the procedure needs to be exhorted.

The most common post-procedural complication is pneumothorax (without the need for intervention) [1,2]. Pneumothorax requiring intervention is much lower due to the fact that maximum of these complications are mild [3,4]. Other complications associated with the procedure are pulmonary hemorrhage (2nd most common), pulmonary hemorrhage extending into the pleural cavity leading to hemothorax, and bronchopleural fistula. The most fatal and very rare complication of the procedure is air embolism. One of the extremely rare complications is needle tract seeding. Other rare complications are hypotension/collapse of the patient due to major vessel injury and death [1].

The size and severity of pneumothorax are measured on axial post-biopsy CT images as the largest distance of retraction of pulmonary surface, classified as Small < 2 cm, Moderate 2 cm -4 cm and Large > 4 cm [5]. Factors associated with complication are; needle path length from the pleura to target, location of the lesion, needle trajectory, fissure puncture, and obstructive lung disease. Emphysema is a significant independent predictor predisposing to pneumothorax and also with increased need for chest tube placement [6], due to decreased pressure effect. Coughing

and Valsalva maneuver during the procedure increases the risk of pneumothorax, hemorrhage, and very severe air embolism. Lesions in the lower lobe pose a higher risk of pneumothorax possibly due to greater respiratory motion in the lower lobe, whereas lesions in the upper and middle lobes indicate a higher risk of the need for chest tube placement once pneumothorax had occurred [6]. Fissure puncture is also an independent risk factor, as a transgression of many pleural surfaces by a biopsy needle increases the risk of pneumothorax [5].

Methodology

This was a single-center study conducted in our institution to study the complications of CT-guided lung biopsy and its determinants. The suspected cases of lung carcinoma prescribed for CT-guided lung biopsy attending various departments were included. Of these 123 patients fulfilling the inclusion criteria and giving their consent for inclusion in the study were enrolled. Pre-procedural investigations like; CBC (Complete blood count), PT/INR (Prothrombin Time/ International normalized ratio), and viral markers were carried out. Any current medication regime of the patient was asked about pertaining to the preprocedural management/ precaution.

Access route was planned after taking a baseline CT to map out the shortest and safest pleura to lesion route and avoid the mediastinal structures and major vessels, fissures, and bulla puncture, if possible, in case of emphysematous lung. If the lesion was seen adjacent to the major vessel a post-contrast scan was taken.

Post-procedural monitoring was done for at least four 4 hours to see any complications. If an immediate post-biopsy scan showed mild pneumothorax, it was followed by further check scans for any progression following the low-dose radiation protocol. In case of advancing or large pneumothorax, ICD placement was done. Pneumothorax was measured as the widest distance retracted pleura from the chest wall largest distance of retraction of the pulmonary surface.

Statistical analysis

The statistical analysis was done using SPSS (Statistical Package for Social Sciences) Version 21.0 Statistical Analysis Software. The data obtained during the study was obtained and tabulated and the significance was calculated with the Chi-squared test and the *p* - values obtained.

Results

A total of 123 biopsies were performed. The most common complication encountered was pneumothorax in the study accounting for ~ 22% i.e. in 27 subjects (Table 1). Mild pneumothorax was observed in 19 (70.4%) moderate in 5 (18.5%) and Severe pneumothorax in 3 (11.1%). Post-biopsy intervention was required in only 6 patients (4.8%). 14 out of 27 subjects showed spontaneous complete pneumothorax resolution within 24 hours and of them, 12 subjects showed reduction in pneumothorax within 4 hours. 13 patients showed resolution more than 24 hours (Table 2).

A significant association of pneumothorax with the shortest pleural lesion distance and with traversed lung distance ($p = 0.009$) was found. More no. of cases were seen with longer needle paths vis a vis larger depth of the lesion. Significant association of pneumothorax seen with an acute needle to thoracic wall angle ($p = 0.01$), fissure penetration ($p = 0.02$), and underlying emphysema ($p = 0.01$).

Multivariate assessment in our study showed a significant association of pneumothorax complication with underlying emphysema as the independent factor (Table 3).

Table 1: Frequency of Complications.

SN	Complications	No. of patients	Percentage
	Pneumothorax	27/123	22%
	Mild	19/27	70%
	Moderate	5/27	18%
	Severe	3/27	11%

Table 2: Requirement of Intervention and Resolution of Pneumothorax ($n = 27$).

SN	Pneumothorax	No. of patients	Percentage
1-	Intervention required	6	22.2
2-	Reduction in 4 hours	12	44.4
3-	Complete resolution <24 hours	14	51.9
4	Complete resolution within >24 hours	13	48.1

Table 3: Association of pneumothorax with various determinants.

Shortest pleural lesion distance	Total	Pneumothorax. (n=27)	
		No.	%
<1 cm	95	17	63.0
1-2 cm	18	4	14.8
>2 cm	10	6	22.2
	χ^2		9.363
	'p'		0.009
TLD			
<1 cm	88	14	51.9
1-2 cm	16	4	14.8
>2 cm	19	9	33.3
	χ^2		9.126
	'p'		0.010
NTWA			
<50 degree	8	2	7.4
50-69 degree	37	15	55.6
70-89 degree	65	8	29.6
≥90 degree	13	2	7.4
	χ^2		11.362
	'p'		0.010
Fissure penetration	Total		
Absent	116	23	85.2
Present	7	4	14.8
	χ^2		5.365
	'p'		0.021
Underlying emphysema			
Absent	114	22	81.5
Present	9	5	18.5
	χ^2		6.400
	'p'		0.011

Table 4: Multivariate analysis for Pneumothorax Complication.

Variables	B	S.E.	Wald	df	Sig.	Exp(B)	95% CI	
							Lower	Upper
SPLD	0.094	0.620	0.023	1	0.879	1.099	0.326	3.703
TLD	0.591	0.510	1.345	1	0.246	1.806	0.665	4.906
Fissure penetration	1.347	0.878	2.353	1	0.125	3.846	0.688	21.505
Underlying emphysema	1.804	0.743	5.898	1	0.015	6.075	1.416	26.054
Constant	-1.912	0.313	37.268	1	< 0.001	0.148		

The association of pneumothorax with the nodule size was calculated, however, no significant *p* - value was obtained, but more cases with the complication were seen with lesion size within the range of 2 cm – 5 cm. Since lesion sizes < 2 cm were very few, a significant *p* - value was not obtained (Table 4).

Discussion

Pneumothorax was the most common complication seen in 22% of patients. Only 4.8% of cases of major complications as severe pneumothorax required intervention.

There was an increased rate of pneumothorax seen with increased lesion depth and traversed lung distance as there was more aerated lung passage and greater difficulty encountered in the needle passage up to the lesion. In our study, there was a total of 10 lesions with a depth of > 2 cm from the pleura i.e., the shortest pleural lesion distance, of them with 6 lesions post biopsy pneumothorax was seen i.e., in about 60%. Traversed lung distance of > 2 cm was seen in 19 lesions with 9 of them developing pneumothorax i.e., in about 47.4%.

In the study by Elshafee, et al. a retrospective evaluation of 311 biopsy procedures, it was seen that there was a significant association of pneumothorax with lesion depth [3]. The study by Nour eldin, et al. including 650 patients determining risk factors related to the development of pneumothorax through CT-guided biopsy of pulmonary lesions in coaxial and non-coaxial techniques, found a significant association of pneumothorax development with increased needle track path of > 2.5 cm in both the groups [7]**.** In a study by Li, et al. 169 patients were biopsied all with lesion size ≤ 20 mm lesions, so the lesion size was the constant factor here. It was found that a pleural distance of > 21 mm was a significant risk factor involved in the incidence of pneumothorax [5].

In some studies, however, subpleural lesions are the more significant associated factors for pneumothorax [8]. Yeow, et al. conducted a study over 117 patients and found that subpleural lesions of 2 cm or shorter in depth posed a higher risk for pneumothorax (represented 33% of lung lesions, and caused 71% of all pneumothoraces) [9]. However, in our study most of the lesions with pleural depth < 2 cm were also within the size range of 2-5 and > 5 cm, which in itself is the negative predictor.

The more the acute angle more the possibility of the complication of pneumothorax is explained by the oblique puncture of the pleura leading to more surface area of the damaged pleura. In our study, there were 37 lesions approached with acute angle within the range of 50-69 degrees of which 15 developed pneumothoraxes i.e., 40.5%. Only 12.3% and 15.4% of cases of complications were seen in the lesions approached with needle angles within the range of 70 - 89° and ≥ 90 ° respectively. Hence it is advisable to keep a perpendicular needle pleura interface, however, in some cases, it cannot be avoided altogether due to lesion location, like a lesion with respect to the posterior mediastinal pleura.

In a study conducted by Saji, et al. over 289 patients underwent biopsy with a 19G TMC needle, and 77 patients (26.6%) had pneumothorax after percutaneous CT-guided lung biopsy. Forty-one of the 77 patients (53.2%) who had pneumothorax (14.2% of the entire series) required chest tube placement. It was confirmed that lesion depth and wider needle trajectory were independent risk factors for pneumothorax [10]. Hiraki, et al. analyzed 1,098 CT fluoroscopy-guided lung biopsies conducted with 20-gauge coaxial cutting needles for 1,155 lesions in 1,033 patients to evaluate the incidence of pneumothorax and chest tube placement, and the independent risk factors involved. In their study needle trajectory angle of < 45° showed a significant independent association for pneumothorax complication [6].

Of the 7 cases of fissure puncture encountered in our study, four of the cases developed immediate post-biopsy pneumothorax, with no need for intervention.

Emphysema was seen as an independent risk factor for pneumothorax. Of the 9 cases in our study with the traversed emphysematous lung parenchyma, 6 cases developed a post-biopsy complication, 4 were pneumothorax, one developed pulmonary haemorrhage with pneumothorax and one case developed pulmonary haemorrhage only. The lesions in the rest of the cases were seen close to the pleura with no obvious intervening lung parenchyma.

Most of the studies have shown that emphysema is an independent and significant risk factor with a strong association with post-biopsy pneumothorax, since there is air trapping in the parenchyma with reduced elasticity there are more chances of air escape into negative pressure pleural space after the biopsy [7,11]. In a retrospective study by Elshafee, et al. of 311 biopsies with a non-coaxial semi-automated 18G biopsy system, it was found that emphysema

and fissure puncture were an independent risk factor for the pneumothorax [5]. Hiraki, et al. in a study of over 1098 CT-guided lung biopsies calculated from the univariate as well as multivariate analyses that emphysema is an independent risk factor for pneumothorax post-intervention [6].

The rate of pneumothorax in the study was seen to be greater with the smaller lesion, however, a significant *p* - value was not obtained. In the study, 10 lesions with a size < 2 cm, and 4 of them developed pneumothorax i.e., in 40% of the cases. 47 lesions were in the size range of 2 cm - 5 cm, of them 13% of cases showed pneumothorax, and 66 lesions with a size range above 5 cm showed the complication.

There is a significant association between the lesion size and incidence of complication since small lesions are associated with more traversed lung parenchyma, more needle manoeuvre, and increasing chances of pleural injury and procedural time [12]. Subpleural small lesions also pose a similar problem. Moreover, small lesion biopsy led to more adjacent parenchymal injury with their sampling and also there is less tamponade effect leading to incidence of pneumothorax. Nour eldin, et al. study conducted over 650 patients noted the significant association of pneumothorax with smaller lesion size (< 2 cm) [7]. In another study by Covey, et al. over 443 patients undergoing a biopsy, found that decreased lesion size is a significant predictor of complication [13].

In our study, mild pneumothorax cases were 19 (70%), moderate 5 (18.5%), and severe cases in only 3 cases (11.1%), in the immediate post biopsy scan (Table 1). Of the 27 cases, 14 cases (51.9%) showed spontaneous resolution within 24 hours with 12 cases showing reduction within 4 hours of follow-up post biopsy scan. The rest of the 13 cases (48.1%) showed resolution after 24 hours on follow-up with ICD (Intercostal drainage) required in only 6 of the cases presenting with severe breathlessness i.e. rate of intervention was only 22.2% of the total pneumothorax with overall rate of intervention being low i.e., 4.8% (Table 2) with only 5 of them was intervened with ICD placement on the same day showing enlargement in pneumothorax on 4 hours follow up scan, with only one of them intervened on the next day presenting with breathlessness and scan showing enlarging pneumothorax. 3 of these cases showed only mild pneumothorax earlier in immediate post-biopsy scan thus requiring and stating the need for a follow-up scan. The drain was removed two to 3 days after the intervention in four of them. In one case drain was removed after 6 days and in the other case drain was removed after 10 days.

More cases of post-pneumothorax intervention were seen in men in the study (4 out of 6). Of the 6 cases of pneumothorax requiring intervention, in 4 cases there was an acute (< 70°) needle to pleura angle, one of them being 52 degrees; although lesion size was also small in 3 of such 4 cases hence the acute angle combined with small lesion size was found to be a strong predisposing factor for the development of pneumothorax in these cases**.** Only 1 case with acute needle pleura angle was also associated with traversed lung distance > 2 cm. 9 cases of biopsy involving traversed emphysematous parenchyma only 3 required interventions (Table 3).

ICD rate varies from 2% - 15% stated by the Journal of Vascular and Interventional Radiology [14]. In a retrospective study by Hiraki, et al. on 1,098 CT fluoroscopy-guided lung biopsies conducted with 20-gauge coaxial cutting needles for 1,155 lesions in 1,033 patients; the overall incidence of pneumothorax was 42.3%, ICD in 11.9% of cases. The significant risk factors for the chest tube placement were emphysema and greater lesion depth [6]. In the study by Saji, et al. involving 289 patients who underwent biopsy using only one type of needle, the 19-G, 26.6% of cases had pneumothorax, and 53.2% of them who had a pneumothorax (14.2% of the total cases) required chest tube placement. It was found that a wider trajectory needle and greater lesion depth were associated with post-biopsy pneumothorax intervention [10].

In our study there was a significant association seen in post-biopsy intervention and needle pleura interface angle similar to the study by Saji, et al. However some studies stated other factors also involved in the post-biopsy intervention like; emphysema and greater lesion depth, while others stated greater lesion depth, age, history of smoking, and no. of pleura puncture i.e. fissure penetration [6,13]. More cases of pneumothorax were seen in female patients dissimilar to previous studies. Some studies suggest that men are more prone to the development of pneumothorax and also more prone to intervention due to persistent air leakage that occurs as men have greater vital capacity but no significant value was obtained in our study [6].

Pneumothorax incidence was seen associated with greater lesion depth, greater traversed lung parenchyma, acute needle and pleural interface angle, needle traversing through the emphysematous parenchyma, and fissure puncture hence the more perpendicular approach and avoiding the bullae in case of the emphysematous lung were more important consideration in our study to reduce the complication of pneumothorax.

Conclusion

Pneumothorax is the most common complication of CT-guided lung biopsy. A very low rate of severe pneumothorax was observed post biopsy with more than half cases showing resolution within 24 hours. We thus conclude from the observations of our study that there was a statistically significant correlation between the risk of pneumothorax post-biopsy with the length of the needle traversing the lung parenchyma, the angle of the needle with the chest wall,

and the depth of penetration of the fissure. The presence of emphysema and fissural puncture were independent risk factors for developing pneumothorax as observed in our study and its presence should make the radiologist take an extra cautious approach during biopsy to reduce the degree and severity of the pneumothorax and remain vigilant in cases of fissural puncture in post biopsy check scans.

To conclude, accepting mild pneumothorax as a common and non-amenable complication of lung biopsy should be understood and adequate steps taken to ensure that its incidence and severity are as low as possible keeping in view of the variables associated with its incidence and severity.

Ethics approval

Proper ethics approval and clearance were provided by the Dean's academic society of the institution, Dr Ram Manohar Lohia Institute of Medical Sciences, Gomti Nagar, Lucknow, India in 2019. The internal review board number for this study is RMLIMS/IEC No. 44/19.

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