Original Article

Received: 2022-08-10
Accepted: 2022-10-10

BCCR
2022, No 1, Vol 14 :44-51
www.bccrjournal.com

Computed Tomography Guided Transthoracic Lung Biopsy: Evaluating Risk Factors of Post-Procedure Pneumothorax- A Multivariate Analysis

Faiz Altaf Shera[1*], Shera Tahleel Altaf[1], Shah Omair Ashraf[1], Robbani Irfan[1], Choh Naseer Ahmad[1], Gojwari Tariq Ahmad[1], Dar Abdul Majeed[2], Shah Sonaullah[3]

1. Department of Radio-Diagnosis and Imaging, Sher-i-Kashmir Institute of Medical Sciences, Soura, Srinagar, Jammu and Kashmir, India
2. Department of Cardiovascular and Thoracic Surgery, Sher-i-Kashmir Institute of Medical Sciences, Soura, Srinagar, Jammu and Kashmir, India.
3. Department of Internal and Pulmonary Medicine, Sher-i-Kashmir Institute of Medical Sciences, Soura, Srinagar, Jammu and Kashmir, India.

*Corresponding author:
Dr. Faiz Altaf Shera,
Department of Radio-Diagnosis and Imaging, Sher-i-Kashmir Institute of Medical Sciences, Soura, Srinagar, Jammu and Kashmir, India 190011

Email: faizshera@gmail.com,

Phone number: +919419081118

ABSTRACT

Background: CT Guided lung biopsy is a common procedure in our department and pneumothorax is one of its commonest complications. To study the incidence of pneumothorax after CT guided lung biopsy and the various factors associated with the risk of developing pneumothorax after biopsy.
Materials and Methods: Our study was a retrospective observational study. We analyzed 360 cases of lung biopsy performed using 18G Coaxial needle for assessing the incidence of post- procedure pneumothorax. The risk factors for pneumothorax were evaluated by univariate analysis, followed by multivariate logistic regression analysis to know the independent risk factors of pneumothorax.
Results: The incidence of pneumothorax in our study was 41.9% (151/360 cases). On univariate analysis, we identified the following as risk factors of post-procedure pneumothorax: the presence of emphysema, smaller lesion size, Greater lesion depth, Lateral position, multiple passes and acute angulation of needle trajectory. On multivariate logistic regression analysis these were also revealed to be independent risk factors of post-procedure pneumothorax.
Conclusion: Independent risk factors of post procedure pneumothorax are the presence of emphysema, smaller lesion size, greater lesion depth, Lateral position, multiple passes and acute angulation of needle trajectory. Of these lateral position is a novel predictor of pneumothorax that has been scarcely mentioned in literature. As such the radiologist should be prepared for managing pneumothorax in cases with one or more of these risk factors.

Keywords: Biopsy, CT, Lung, Pneumothorax, Risk factors

INTRODUCTION:

EComputed tomography (CT) guided transthoracic lung biopsy is a routinely performed radiological procedure. However, like any invasive medical procedure, it is associated with its own set of risks and complications. These include pneumothorax, pulmonary hemorrhage, hemoptysis, hemothorax, infection and rarely air embolism and tumor seeding [1, 2]. We as radiologists need to be prepared for these eventualities, as and when they occur. Only by being prepared can we guarantee the highest level of medical care for our patients. In order to do this, we need to be aware of the incidence of these complications, the various risk factors associated with their development and the best ways to manage them when they occur.

Of the various complications associated with CT-guided lung biopsy, pneumothorax is the most common. Many variables have been studied by different researchers as possible risk factors for the development of post-biopsy pneumothorax, often with conflicting results. As such, the variables statistically correlate with the frequency of pneumothorax remains controversial. The variables that are considered to be associated with the development of post-procedure pneumothorax have been traditionally divided into three groups: Patient-related variables, lesion-related variables and procedure-related variables. The patient-related risk factors that have been most commonly described for pneumothorax are the presence of chronic obstructive pulmonary disease (COPD), gender and the lack of a history of ipsilateral surgery. Certain lesion characteristics are also considered to predispose patients to pneumothorax. These include increased depth of the lesion from the skin or long needle path, small lesion size and location of the lesion in the lower lobes of the lungs. Certain procedural factors are also considered to affect the pneumothorax rate in patients undergoing transthoracic lung biopsy. The risk of pneumothorax has been considered to increase with an increased number of pleural punctures, the larger bore of the needle, less experience of the operator and wider insertion angle of the needle—that is, when the needle is inserted less perpendicular to the pleura [2-5]. As such keeping this in mind we conducted our study to know the incidence of pneumothorax in our institute and to identify the various risk factors associated with its development.

Materials and Methods:

Our study was a retrospective observational study that included all cases that underwent CT-guided transthoracic lung biopsy from October 2018 to June 2020. A total of 360 cases of CT-guided transthoracic lung biopsy were included. Ethical clearance was waived off as it was a retrospective study. No funding from any source was received.

Biopsy technique

The procedure was performed by an interventional radiologist experienced in CT-guided biopsy after obtaining informed consent from the patient. All patients underwent diagnostic CT of the chest with 5-mm-thick contiguous axial tomographic sections before the biopsy. The CT unit used in this study was the Siemens SOMATOM Sensation Open Multidetector row 32 slice CT scanner. At the time of biopsy, preliminary helical CT images were obtained in 5-mm-thick sections through the lesion. Imaging parameters during CT image acquisition included a CT beam width collimated to 1.2 mm, tube voltage of 120-kilovolt peak, current of 30 to 50 mAS, and a scanning speed of 0.5s per rotation (360°). From a review of these preliminary images, patient position, level of entry of the needle, and direction of approach for biopsy were planned to provide the most direct route for biopsy, to traverse the least amount of aerated lung, and to avoid bullae and fissures. The positions of patients during biopsy were determined by the size, site, etc. of the lesion. A coaxial biopsy system was used comprising of 17G coaxial cannula and an 18 G core biopsy gun respectively. Both automatic and semi-automatic guns were used.

Intermittent CT images, using the following parameters CT beam width collimated to 1.2 mm, tube voltage of 120-kilovolt peak, current of 20 mAS, and a scanning speed of 0.5s per rotation, were acquired during the procedure to check the course of the needle and confirm its location in the lesion. After confirming that the needle tip

had reached the lesion, a specimen was obtained and the needle is withdrawn if an adequate sample is obtained. If not, additional passes were made to obtain the adequate samples. After the biopsy, all patients were placed in the decubitus position with the biopsy site down.

Data Acquisition and Analysis

Multiple variables related to the patient, lesion, and procedures were collected to determine the risk factors for the occurrence of pneumothorax. The patient variables included: age, gender, the presence of emphysema. The lesion variables included: size (long-axis diameter), lobar location (upper/middle or lower lobe) and lesion depth. The procedure variables included: patient positioning, the number of passes, and the angle of the needle trajectory. The cases were divided into two groups the Pneumothorax group and the no pneumothorax group depending on the development of post-procedure pneumothorax for analysis of risk factors. Qualitative data were analyzed by non-parametric tests like the Chi-square test and Quantitative data was analyzed by using tests like the students t-test for univariate analysis. The variables that were revealed to be significantly different by univariate analyses were subjected to multivariate logistic regression analysis to determine the independent risk factors for the occurrence of pneumothorax. A p-value of < 0.05 was considered to be statistically significant. Statistical analysis was performed using statistics software (SPSS version 22.0).

Results:

360 CT-guided transthoracic lung biopsies were analyzed by us. The study population consisted of 248 males and 112 females. The mean age of the patients in our study was 59.2 ± 13.67 years. . Of these 360 cases 151 developed post-procedure pneumothorax. The incidence of post-procedure pneumothorax was 41.94%.

Univariate Analysis

The cases were divided into two groups for evaluation of risk factors; the pneumothorax group and the no pneumothorax group. Our results showed a statistically significant difference between the two groups in case of the following variables: the presence of emphysema, lesion

Table 1. Univariate Analysis of Risk Factors

Risk Factor	Total (n=360)	Pneumothorax Group (n=151)	No Pneumothorax group (n=209)	P value
Age(in years)	59.2 ± 13.67	60.21± 11.37	58.53± 15.11	0.251
Gender:				
Male	248	104	144	0.996
Female	112	47	65	
Emphysema	148	84	64	≤ 0.0001
Size of lesion(cm)	5.09 ± 2.17	4.28 ± 1.74	5.66 ± 2.26	≤ 0.0001
Depth of lesion(cm)	1.439 ± 1.63	1.73 ± 2.349	0.781 ± 1.17	≤ 0.0001
Location of lesion:				
Upper/Middle lobe	250	108	142	0.467
Lower lobe	110	43	67	
Angle of needle trajectory(in degrees)	70.81± 15.93	67.18 ± 15.65	73.43 d ± 15.66	≤ 0.0001
Number of passes:				
Single	325	117	208	≤ 0.0001
Multiple	35	34	1	
Patient Position:				
Supine	164	65	99	0.007
Prone	154	59	95	
Lateral	42	27	15	

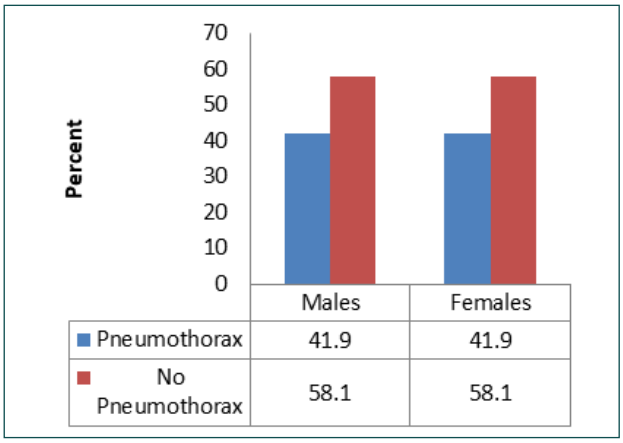

Figure 1. Incidence of Pneumothorax concerning Gender

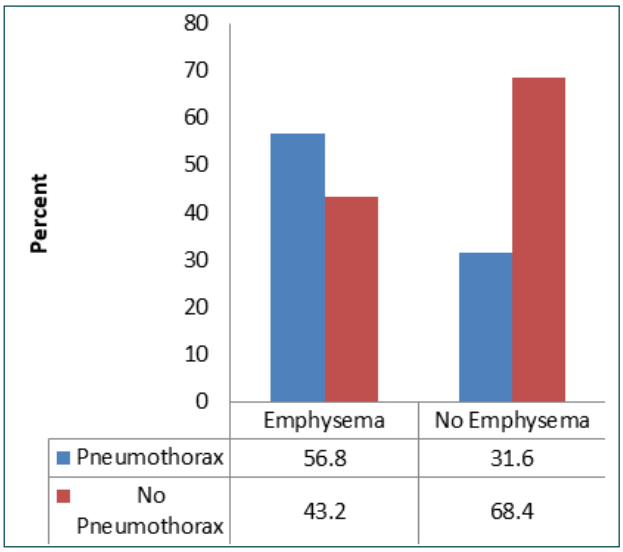

Figure 2. Incidence of Pneumothorax concerning Emphysema

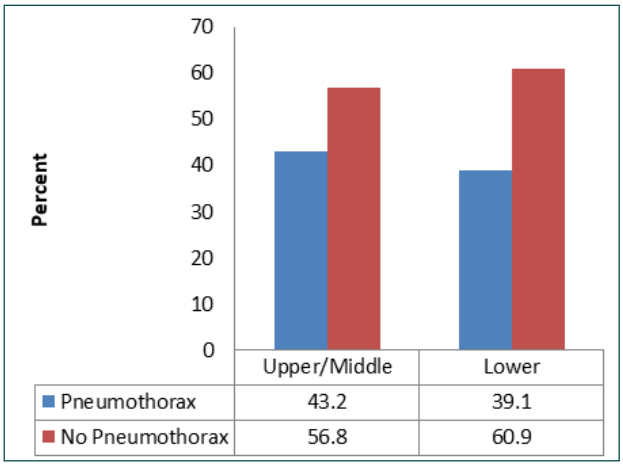

Figure 3. Incidence of Pneumothorax concerning the Location of the lesion

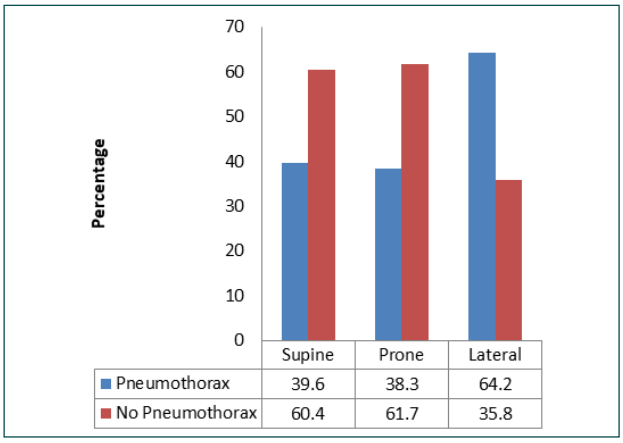

Figure 4. Incidence of Pneumothorax concerning Patient Position

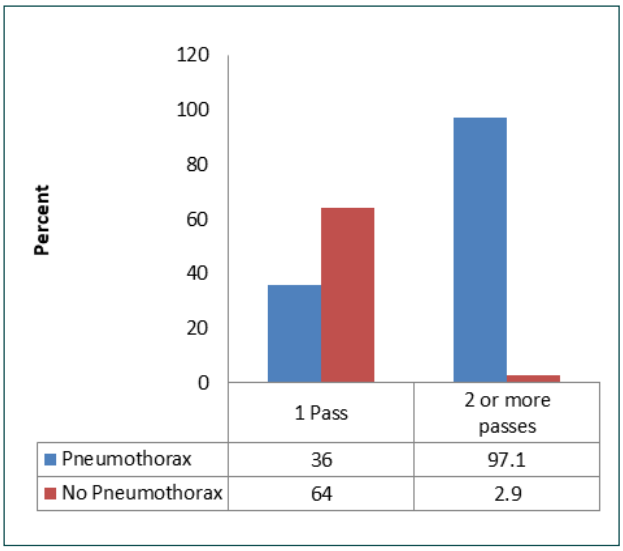

Figure 5. Incidence of Pneumothorax concerning the number of Passes

size, lesion depth, patient position, number of passes and angulation of needle trajectory signifying a correlation with risk of development of pneumothorax. Our results did not show any statistically significant difference between the two groups in case of the following variables: age, gender and location of lesion signifying no correlation with risk of development of pneumothorax. There was a greater risk of pneumothorax in cases with emphysema, smaller lesion size, greater lesion depth, lateral position, multiple passes and acute angulation of needle trajectory. The results are summarized in Table 1, Figures 1-5.

Table 2. Multivariate Logistic Regression Analysis

Risk Factor	Regression Coefficient	Wald value	P value	Odds Ratio	95% Confidence Interval	
					Lower	Upper
Emphysema	-1.560	26.556	<.001	.210	.116	.380
Size of lesion	-.258	10.698	.001	.772	.662	.902
Lesion Depth	.576	28.638	<.001	1.779	1.441	2.198
Angle of needle	-.032	12.187	<.001	.969	.952	.986
No. of Passes	-2.995	8.031	.005	.050	.006	.397
Position	-1.158	5.708	.017	.314	.121	.812

Multivariate Analysis

The six risk factors identified from univariate analysis were further subject to multivariate logistic regression analysis to find out the independent risk factors for the occurrence of post procedure pneumothorax. This was done to rule out any confounding factors. The results showed that all the variables identified as risk factors on univariate analysis were also independent risk factors of pneumothorax on multivariate analysis. The results are summarized in Table 2.

Discussion:

All invasive procedures have a morbidity and mortality rate associated with them, which are important in considering whether to subject the patient to a procedure. Of the various complications of CT-guided transthoracic lung biopsy, pneumothorax is the most common. The asymptomatic rate ranges from 17.5% to 72% [6]. We analyzed 360 cases of CT-guided lung biopsy in 360 patients and of these 151 developed post-procedure pneumothorax. The incidence of pneumothorax in our study was 41.94 %. The incidence of post-procedure pneumothorax in our study was similar to the pneumothorax rates reported by Yamagami T and colleagues in 2002 (34.3%), Yamagami T and co-workers in 2005 (36.7%), Yamagami T et al. in 2009 (38%), Kakizawa H et al. in 2010 (43%), Rizzo S. And colleague's in 2011 (45.8%), Asai N et al. in 2013 (40.2%) and Zhang HF et al. in 2018 (40.18%) [7-13]. However other authors have reported different rates of post-procedure pneumothoraces. Brown KT and co-workers, Laurent F et al., Choi CM et al. , Vatrella A and coworkers, Lim CS et al. and Lim WH and colleagues reported comparatively lower rates of 22%, 19.9%, 21.8%, 7.45%, 29.9% and 27.3 % respectively [14-19]. Whereas on the other hand Klein JS et al. , Nakamura M et al. , Wallace MJ and coworkers reported comparatively higher rates of 54%, 59.6% and 62% respectively [20-22]. This difference in rates of pneumothorax can be easily explained because of the inhomogeneous nature of the various studies. Each of these studies had a different set of patients, lesions and procedural variables that explains this difference in the incidence of pneumothorax in these studies.

Risk Factors for the development of Pneumothorax

Several variables have been evaluated for the risk of development of pneumothorax post CT- guided transthoracic lung biopsy by different investigators. Our results show that the independent risk factors of post-procedure pneumothorax are the presence of emphysema, smaller lesion size, Greater lesion depth, Lateral position, multiple passes and acute angulation of needle trajectory. On the other hand there is no relation with age, gender or lobar location of the lesion.

We consider emphysema to be a significant independent risk factor for the development of post-procedure pneumothorax. This association between emphysema and the risk of post biopsy pneumothorax can be explained by the fact that disruption of dilated air spaces can lead to air leaks and also decreased elasticity of the lungs. Similar results were obtained by Chami HA and coworkers,

Zhang HF et al. and Zhao Y and colleagues [13, 23, 24].

The mean size of lesions in the pneumothorax group was 4.28 ± 1.74 cm. In the no pneumothorax, the mean size of the lesion was 5.66 ± 2.26 cm. The difference was statistically significant implying a correlation between lesion size and risk of pneumothorax with a smaller lesion size (<4.5cm) associated with a greater risk of pneumothorax. This can be explained by the fact that the smaller the lesion the more difficult to obtain adequate biopsy specimens and multiple samples may be required thus increasing the possibility of pneumothorax. In concordance with our study Rizzo S et al., Asai N et al. and Zhang HF and colleagues also consider smaller lesion size a risk factor for pneumothorax development [11-13]. However few other investigators like Hiraki T et al and Zhao Y et al. don't consider lesion size as a risk factor for pneumothorax based on their findings [24, 25].

Increased depth of lesion from the pleural surface is also an independent risk factor for pneumothorax. A possible reason for this is that the deeper the lesion, the more difficult it is to target the lesion. This results in increased trauma to the lungs and pleura. Similar to our results Hiraki T and coworkers, Rizzo S et al. and Chami HA et al. consider lesion depth a significant predictor of pneumothorax [11, 23, 25]. Zhang HF et al. on the other hand showed no correlation between lesion depth and risk of pneumothorax possibly because they excluded all lesions with lesion depths up to 1cm from their study [13]. The lateral position was a significant risk factor for the development of pneumothorax in our study. Most previous investigators have not shown any relation between lateral position and risk of pneumothorax except Zhao Y et. al. Zhao Y et. al concluded that being in the prone or the lateral position was an independent risk factor of a pneumothorax [24]). We believe that lateral position is an unnatural position making it difficult for patients to cooperate during the procedure resulting in pneumothorax. We consider multiple passes (2 or more) to be a significant independent risk factor for pneumothorax. More needle passages led to more visceral pleural injuries, resulting in higher chances of occurrence of pneumothorax. Similar results were obtained by Zhang HF et. al. and Zhao Y et.al. [13, 24]. Whereas Chami HA et al. on the other hand don't consider a number of passes to be a risk factor for pneumothorax. Although not statistically significant on multivariate analysis the pneumothorax rate in the group with 2 or more passes (46%) was higher than in those with a single passes (29%) in their study [23].

The angle of needle trajectory is also an independent risk factor for pneumothorax. The risk of pneumothorax is greater with fewer perpendicular angles which leads to injury to the pleura.

However, our study does have a few limitations. We did not include some risk factors like procedure time, ipsilateral lung surgery and operator experience. Also, some patients may have developed delayed pneumothorax and may have been missed.

Conclusion:

In conclusion, pneumothorax is a common complication of CT-guided transthoracic lung biopsy and we can be prepared for it by our knowledge of the risk factors associated with the development of pneumothorax. We consider the following variables to be independent risk factors for the occurrence of pneumothorax: the presence of emphysema, smaller lesion size, greater lesion depth, lateral position, multiple passes and acute angulation of needle trajectory. Age, gender and the location of lesion are not associated with the risk of development of pneumothorax. Lateral Position is a new predictor of pneumothorax that has been scarcely mentioned in the literature previously and requires further studies.

Conflicts of Interest:

The Authors declare that there is no conflict of interest.

Financial Disclosures:

None

REFERENCES

1. Boskovic T, Stanic J, Zarogoulidis P et al. Pneumothorax after transthoracic needle biopsy of lung lesions under CT guidance. J Thorac Dis. 2014 March; 6(S1): p.

2. Wu CC, Maher MM, Shepard JO. Complications of CT-Guided Percutaneous Needle Biopsy of the Chest: Prevention and Management. AJR. 2011; 196: p. W678–W682
3. Fish GD , Stanley JH , Miller KS , Schabel SI , Sutherland SE. Postbiopsy Pneumothorax:Estimating the Risk by Chest Radiography and Pulmonary Function Tests. AJR. 1988; 150: p. 71–74.
4. Covey AM, Gandhi R , Brody LA, Getrajdman G, Thaler HT, Brown KT. Factors associated with pneumothorax and pneumothorax requiring treatment after percutaneous lung biopsy in 443 consecutive patients. J Vasc Interv Radiol. 2004; 15: p. 479–483.
5. Khan MF, Straub R, Moghaddam SR et al. Variables affecting the risk of pneumothorax and intrapulmonary hemorrhage in CT-guided transthoracic biopsy. Eur Radiol. 2008; 18: p. 1356–1363.
6. Haaga JR, Haaga TL , Wu H. Image Guided Interventions:CT emphasis. In Haaga J, Dogra V, Forsting M, Gilkeson R, Ha H, Sundaram M, editors. CT And MRI of the Whole Body. 5th ed. Philadelphia.USA.: Mosby.Elsevier.; 2009. p. 2462-2486.
7. Yamagami T, Nakamura T, Iida S , Kato T and Nishimura T. Management of Pneumothorax After Percutaneous CT-Guided Lung Biopsy. Chest. 2002; 121: p. 1159–1164
8. Yamagami T, Kato T, Iida S, Hirota T, Yoshimatsu R, Nishimura T. Efficacy of manual aspiration immediately after complicated pneumothorax in CT-guided lung biopsy. J Vasc Interv Radiol. 2005
9. YamagamiT,Terayama K, Yoshimatsu R , Matsumoto T ,Miura H , Nishimura T. Role of Manual Aspiration in Treating Pneumothorax after Computed Tomography-Guided Lung Biopsy. Acta Radiologica. 2009
10. Kakizawa H, Toyota N, Hieda M et al. Risk factors for severity of pneumothorax after CT-guided percutaneous lung biopsy using the single-needle method. Hiroshima J Med Sci. 2010 Sep; 59(3): p. 43-50.
11. Rizzo S, Preda L, Raimondi S et al. Risk factors for complications of CT-guided lung biopsies. Radiol Med. 2011 Jun; 116(4): p. 548-63.
12. Asai N, Kawamura Y, Yamazaki I et al. Is emphysema a risk factor for pneumothorax in CT-guided lung biopsy? Springerplus. 2013; 2: p. 196.
13. Zhang HF, Liao MY, Zhu DY, Chen J, Wang YF. Lung radiodensity along the needle passage is a quantitative predictor of pneumothorax after CT-guided percutaneous core needle biopsy. Clin Radiol. 2018 Mar; 73(3): p. 319.e1-319.e7.
14. Brown KT, Brody LA, Getrajdman GI ,Napp TE. Outpatient treatment of iatrogenic pneumothorax after needle biopsy. Radiology. 1997; 205: p. 249–252.
15. Laurent F, Michel P, Latrabe V, Tunon de Lara M, Marthan R. Pneumothoraces and chest tube placement after CT-guided transthoracic lung biopsy using a coaxial technique : incidence and risk factors. AJR. 1999; 172: p. 1049–1053.
16. Choi CM, Um SW, Yoo CG, et al. Incidence and Risk Factors of Delayed Pneumothorax After Transthoracic Needle Biopsy of the Lung. Chest. 2004; 126: p. 1516–1521.
17. Vatrella A, Galderisi A, Nicoletta C et al. Age as a risk factor in the occurrence of pneumothorax after transthoracic fine needle biopsy: our experience. Int J Surg. 2014; 12(Suppl 2): p. S29-S32.
18. Lim CS, Tan LE, Wang JY et al. Risk factors of pneumothorax after CT-guided coaxial cutting needle lung biopsy through aerated versus nonaerated lung. J Vasc Interv Radiol. 2014 Aug; 25(8): p 1209-12
19. Lim WH, Park CM, Yoon SH et al. Time-dependent analysis of incidence, risk factors and clinical significance of pneumothorax after percutaneous lung biopsy. Eur Radiol. 2018; 28(3): p. p1328-1337.
20. Klein JS, Salomon G, Stewart EA. Transthoracic needle biopsy with a coaxially placed 20-gauge automated cutting needle: results in 122 patients. Radiology. 1996; 198: p. 715-720.
21. Nakamura M, Yoshizako T, Koyama S, Kitagaki H. Risk factors influencing chest tube placement among patients with pneumothorax because of CT-guided needle biopsy of the lung. J Med Imaging Radiat Oncol. 2011; 55: p. 474–478.
22. Wallac MJ, Krishnamurthy S. ,Broemeling LD et al. CT-guided percutaneous fine-needle aspiration biop-

sy of small (< or =1-cm) pulmonary lesions. Radiology. 2002;225(3):823-828.
23. Chami HA, Faraj W, Yehia ZA et al. Predictors of pneumothorax after CT-guided transthoracic needle lung biopsy: the role of quantitative CT. Clin Radiol. 2015 Dec; 17(12): p. 1382-7.
24. Zhao Y, Wang X, Wang Y, Zhu Z. Logistic regression analysis and a risk prediction model of pneumothorax after CT-guided needle biopsy. J Thorac Dis. 2017 Nov; 9(11): p. 4750–4757.
25. Hiraki T, Mimura H, Gobara H, et al. CT fluoroscopy-guided biopsy of 1,000 pulmonary lesions performed with 20-gauge coaxial cutting needles: diagnostic yield and risk factors for diagnostic failure. Chest. 2009; 136: p. 1612 –1617.