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Diagnostic Efficacy of Transthoracic Fine Needle Aspiration Biopsy in Lung Lesions and Comparative Evaluation of Complications with the Literature

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ABSTRACT

Introduction: We aim to examine the diagnostic accuracy and complication profile of computed tomography (CT)-guided transthoracic fine needle aspiration biopsy (TTFNAB) in patients presenting with pulmonary lesions, while also reviewing these outcomes in light of current literature.

Methods: This retrospective study included 102 patients who underwent CT-guided TTFNAB between April 2020 and June 2022 at a tertiary care center. All procedures were carried out by three radiologists, each possessing a minimum of two years of experience in the field of interventional radiology. Diagnostic yield, complication rates (pneumothorax, hemorrhage, hemoptysis), and lesion characteristics were recorded. Results were statistically analyzed and compared with recent literature.

Results: TTFNAB provided a diagnostic yield of 98%. Malignancy was detected in 76.5% of cases, with adenocarcinoma and squamous cell carcinoma being the most common subtypes. Pneumothorax occurred in 12.7% of cases, tract-perilesional hemorrhage in 21.6%, and hemoptysis in 2%. Lesions located away from the pleura had significantly higher pneumothorax and bleeding rates ($p=0.013$ and $p=0.0005$, respectively). No significant correlation was found between complication rates and gender, lesion location, presence of emphysema, or procedure position.

Conclusion: CT-guided TTFNAB is a highly effective and relatively safe diagnostic tool for lung lesions. While complication rates are acceptable, lesion proximity to the pleura significantly influences risk. Findings are consistent with the literature and support the continued use of TTFNAB in appropriate clinical settings.

Keywords: Computed tomography, transthoracic lung biopsy, fine-needle aspiration biopsy, pneumothorax

Introduction

Lung lesions are commonly seen in clinical settings, and accurate histopathological diagnosis is essential for appropriate management. Among image-guided biopsy techniques, computed tomography (CT)-guided transthoracic fine needle aspiration biopsy (TTFNAB) remains a widely used method because of its non-invasive approach and excellent diagnostic accuracy, particularly in the evaluation of suspected malignancies. Compared to core biopsy techniques, TTFNAB offers the advantage of reduced complication risks due to the use of thinner needles (1). However, concerns remain regarding sample adequacy and diagnostic reliability. The aim of this study is to evaluate the diagnostic effectiveness and complication profile of TTFNAB in a series of patients with lung lesions, as well as to analyze these outcomes in the context of recent literature.

Methods

Lung biopsies performed between April 2020 and June 2022 were retrospectively reviewed, and all participants provided informed consent. The study was approved by the University of Health Sciences Türkiye, İstanbul Education and Research Hospital, Clinical Research Ethics Committee (approval number: 202, date: 17.06.2022). The study included patients with non-diagnostic bronchoscopic biopsy results and those unsuitable for bronchoscopy. These patients were referred for transthoracic biopsy. Patients were excluded if they had lesions smaller than 5 mm, suspected vascular

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lesions, uncorrectable coagulopathy [international normalized ratio (INR) >1.5 or platelet (PLT) <50,000], inability to comply with biopsy positioning, or failure to discontinue anticoagulant/antiplatelet medications 3-7 days prior to the intervention. A total of 102 patients were included in the study. In our study, the biopsy procedure could not be performed in only one patient due to an inability to position the patient properly because of scoliosis. Therefore, this patient was excluded from the study. All biopsies were carried out with a Toshiba Aquilion 128-slice CT scanner by three different radiologists, each possessing a minimum of two years of experience in interventional radiology. Based on prior thoracic CT images, patients were positioned in prone, supine, or lateral decubitus positions to optimize the shortest and safest access to the lesion. To determine the biopsy trajectory, metallic markers were placed on the patient's skin, and a pre-biopsy CT scan was performed using 20 mAs, 120 kV, and a slice thickness of 5 mm. The biopsy needle entry site was identified and marked. After disinfecting the area with povidone-iodine, 2% lidocaine was administered for local anesthesia. A 22G fine needle (Egemen TMT) was used in all procedures. During the procedure, CT imaging was used to confirm the correct placement of the needle within the lesion. Patients were instructed to hold their breath for the duration of the procedure. Aspiration was performed, and the needle was withdrawn along the same trajectory.

The adequacy of the aspirated material was immediately evaluated in the procedure room by a cytopathologist. In cases where the sample was considered to lack sufficient cellularity for diagnosis, a second aspiration biopsy was performed in some patients upon the recommendation of the cytopathologist and approval of the interventional radiologist.

Post-procedural thoracic CT scans were performed to assess complications such as pneumothorax or bleeding. Small pneumothorax cases were managed conservatively with 4-6 days of radiographic follow-up, while large ones (greater than 3 cm or involving more than 30% of the hemithorax) required chest tube drainage and 24-hour hospital observation. CT-guided TTFNAB samples are presented in Figure 1. Lesion size was measured based on the longest axis on CT, and diagnostic adequacy was determined according to pathology reports. Patients without pathology reports were excluded from the study.

Statistical Analysis

Statistical analyses were conducted using SPSS 23.0 (IBM). Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequency and percentage. Group comparisons were performed using the chi-square test, Fisher's exact test, t-test, and Mann-Whitney U test, with a statistical significance threshold set at $p<0.05$.

Results

A total of 102 patients were included, of whom 78 were male and 24 were female, with a mean age of 63±11.52 years. The average lesion size was 30.08 mm. The majority of lesions were found in the upper lobes of the lungs. Demographic data, lesion characteristics, and statistical values are presented in Table 1. Pathological analysis revealed a diagnostic yield of 98%. Malignant diagnoses included adenocarcinoma (23.5%), squamous cell carcinoma (23.5%), and metastases (13.7%) (Table 2). Pneumothorax occurred in 12.7% (13 patients). Only 1 required chest tube insertion. Tract-perilesional hemorrhage was observed in 21.6% (22 patients). Hemoptysis occurred in 2 percent of patients (2 patients). No complications were reported in 63.7% of cases. In patients who developed pneumothorax, one out of 13 in the TTFNAB required chest tube insertion and was monitored in the hospital for at least 24 hours. All other complications resolved spontaneously after follow-up without the need for hospitalization. Pneumothorax was significantly more common in lesions not in contact with the pleura (p=0.013). Regarding the average pleural lesion distance, the TTFNAB group had a p-value of 0.085.

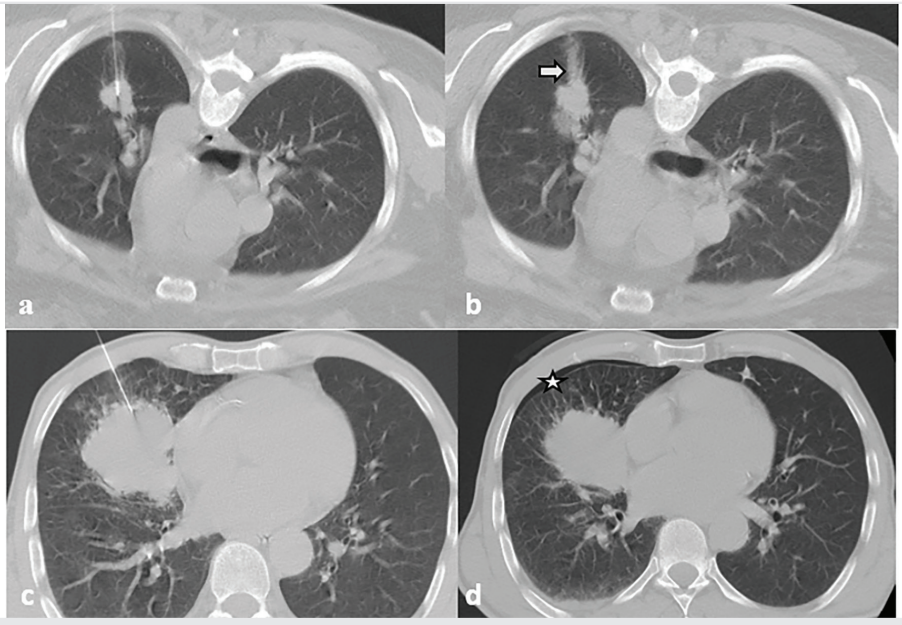

Figure 1. TTFNAB samples in images (a, c) tract and perilesional hemorrhage complications are indicated by the thick, outlined white arrow in image (b) pneumothorax complication samples are marked with a star in image d.
TTFNAB: Transthoracic fine needle aspiration biopsy

Table 1. Demographic data lesion characteristics, and statistical values

	TTFNAB
Age (years)	63 (SD = +/- 11.52) min.:36/-max.:88
Sex Female Male	 24 78
Lesion locations Right upper lobe Right middle lobe Right lower lobe Left upper lobe Left lower lobe	 27 5 13 34 23
Patient positioning during procedure Lateral decubitis Supine Prone	 14 26 62
Transfissural access Yes No	 21 81
Emphysema Yes No	 41 61
Pneumotorax Yes No	 13 89
PX Treatment Thorax tube Follow	 1 12
Pathology Benign Atypia Malignant Nondiagnostic	 18 4 78 2
Hemorrhage Yes No	 22 80
Hemoptysis Yes No	 2 100
Lesion Characteristics Solid Semisolid Ground glass	 83 16 3
Cavitations Yes No	 26 76
Calcifications Yes No	 13 89
Air bronchogram Yes No	 19 83
Average lesion size	30.08 mm (SD =15.35) (min.:9 mm max.:100 mm)
Lesion-pleura relation Pleura based Distant from pleura	 42 60
Average lesion-pleura distance	14.1 mm SD =13.71 (min.:0 max.: 41 mm)

TTFNAB: Transthoracic fine needle aspiration biopsy, SD: Standard deviation, Min.: Minimum, Max.: Maximum

Table 2. Pathological findings

Pathological daignosis	TTFNAB	Rate (%)
Adenocarcinoma	24	23.53
Squamous cell cancer	24	23.53
Small cell lung cancer	4	3.92
Non-small cell lung cancer	4	3.92
Metastasis	14	13.73
Inflamatory findings	8	7.84
Atypical cell	4	3.92
Granulomatous reaction	2	1.96
Neuroendocrine tumor	1	0.98
Lung parencyhma and blood cells	4	3.92
Non-diagnostic material	2	1.96
Hamartoma	2	1.96
B-cell lymphoma	2	1.96
Giant cell pleomorphic sarcoma	1	0.98
Spindle cell carcinoma	2	1.96
Solitary fibrous tumor	2	1.96
Pleomorphic Rhabdomyosarcoma	2	1.96

TTFNAB: Transthoracic fine needle aspiration biopsy

Although this result did not reach statistical significance, it was close to the conventional threshold, suggesting a potential association. In TTFNAB patients, no statistically significant association was observed between pneumothorax complications and gender, lesion location, presence of emphysema, transfissural access, patient position during the procedure, average number of biopsies, and average lesion size ($p>0.05$) (Table 3).

In terms of tract-perilesional hemorrhagic complications, bleeding was observed more frequently in lesions not located on the pleura compared to pleural-based lesions; and this difference was statistically significant ($p=0.0005$). Similarly, as the average pleural distance increased, the incidence of tract-perilesional bleeding also increased significantly ($p=0.0004$). Although an increasing trend in hemorrhagic complications was observed with a higher number of biopsies, this was not statistically significant ($p=0.158$). Furthermore, no statistically significant association was found between tract-perilesional bleeding and gender, lesion location, presence of emphysema, transfissural access, patient position, or lesion size ($p>0.05$) (Table 4).

Discussion

CT-guided TTFNAB is a widely used and reliable method in the diagnosis of pulmonary lesions due to its high diagnostic accuracy and acceptable complication profile (2). It is especially preferred in cases when bronchoscopic access is not possible, in newly developing or enlarging nodules and masses, in patients with multiple nodules, or in those with persistent infiltrative lung disease where diagnostic yield cannot be obtained through sputum culture or bronchial lavage. It is also effective

Table 3. The statistical relation between cases with pneumothorax complications and other clinical or procedural findings

		TTFNAB			
		Pneumotorax			
		Yes	No	Total	p
Sex	Male	8	70	78	p=0.31
	Female	5	19	24	
Lesion locations	Right upper lobe	6	21	27	
	Right middle lobe	0	5	5	
	Right lower lobe	1	12	13	p=0.45
	Left upper lobe	3	31	34	
	Left lower lobe	3	20	23	
Lesion-pleura relation	Pleura based	1	39	40	p=0.013
	Distant from pleura	12	50	62	
Emphysema	Yes	5	36	41	p=0.89
	No	8	53	61	
Transfissural access	Yes	4	17	21	p=0.33
	No	9	72	81	
Patient positioning during procedure	Lateral decubitis	1	13	14	
	Supine	6	20	26	p=0.143
	Prone	6	56	62	
Average lesion-pleura distance (mm)		19.62 mm (SD =9.97)	13.29 mm (SD =14.03)	14.1 mm (SD =13.71)	p=0.085
Average number of biopsies		1.62 (SD =0.5)	1.46 (SD =0.5)	1.48 (SD =0.5)	p=0.458
Average lesion size (mm)		27.31 mm (SD =21.15)	30.48 mm (SD =14.42)	30.08 mm (SD =15.35)	p=0.187

TTFNAB: Transthoracic fine needle aspiration biopsy, SD: Standard deviation

Table 4. The statistical relation between cases with tract-perilesional hemorrhage complications and other findings

		TTFNAB			
		Tract-perilesional hemorrhage			
		Yes	No	Total	p
Sex	Male	18	60	78	p=1
	Female	4	20	24	
Lesion localisations	Right upper lobe	8	19	27	
	Right middle lobe	0	5	5	
	Right lower lobe	4	9	13	p=0.46
	Left upper lobe	6	28	34	
	Left lower lobe	4	19	23	
Lesions-pleura relation	Pleura based	2	38	40	p=0.0005
	Distant from pleura	20	42	62	
Emphysema	Yes	9	32	41	p=0.947
	No	13	48	61	
Transfisurral access	Yes	8	13	21	p=0.53
	No	14	67	81	
Patient positioning during procedure	Lateral decubitis	3	11	14	
	Supine	6	20	26	p=0.93
	Prone	12	50	62	
Average lesion-pleura distance (mm)		26.41 mm (SD =12.29)	10.71 mm (SD =12.09)	14.1 mm (SD =13.71)	p=0.0004
Average number of biopsies		1.64 (SD =0.49)	1.43 (SD =0.5)	1.48 (SD =0.5)	p=0.158
Average lesion size (mm)		27.77 mm (SD =14.14)	30.87 mm (SD =15.72)	30.08 mm (SD =15.35)	p=0.381

TTFNAB: Transthoracic fine needle aspiration biopsy, SD: Standard deviation

in diagnosing hilar lesions inaccessible via bronchoscopy and chest wall masses. However, TTFNAB is contraindicated in certain clinical scenarios such as severe coagulopathy (PLTs <50,000/mm³, INR >1.5), the need for mechanical ventilation, advanced chronic obstructive pulmonary disease, severe pulmonary hypertension, patient non-cooperation during the procedure and vascular lesions (2,3).

In our study, the diagnostic accuracy of TTFNAB was found to be 98%. This rate is higher than the findings of Yao et al. (4), who reported a diagnostic yield of 78.9%, and Heyer et al. (5), who reported 82%. The presence of a pathologist during TTFNAB procedures, enabling immediate evaluation of the specimen, providing feedback on its adequacy, and allowing for repetition of the procedure if necessary, increases the diagnostic yield (6,7). In a study by Santambrogio et al. (8), the diagnostic rate was found to be higher in cases where a pathologist was present during the biopsy compared to those performed without a pathologist. In our study, a cytopathologist was present during all TTFNAB procedures, allowing for immediate evaluation of the samples. Repeat biopsies were performed when necessary. We believe that this practice may have contributed to the high diagnostic accuracy.

One of the most prevalent complications associated with TTFNAB is pneumothorax. Its incidence has been reported to range between 10% and 45% in the literature (9). In our study, the pneumothorax rate was 12.7%, consistent with previous findings. Factors believed to elevate the risk of pneumothorax include small lesion size, deep lesion location, lower lobe involvement, inability of elderly patients to hold their breath, fissure penetration, and presence of emphysema (9,10). However, in this study, no significant correlation was observed between pneumothorax and variables such as gender, lesion location, presence of emphysema, transfissural approach, patient positioning, number of biopsy passes, or lesion size. In both this study and the literature, the absence of pleural contact and greater pleural-lesion distance were associated with higher complication risk (11,12).

In cases of pneumothorax larger than 3 cm or accompanied by symptoms such as acute chest pain and dyspnea, needle aspiration or chest tube drainage is recommended (2). The rate of pneumothorax requiring treatment is reported to range between 3% and 15% in the literature (3). In our study, this rate was only 1%, which may reflect careful procedural planning and execution. Advancing the needle during breath-holding, avoiding fissures, bullae, and blebs, and minimizing the needle path length through lung parenchyma are considered effective strategies to prevent pneumothorax (13).

Tract-perilesional hemorrhage is another common complication, reported in 5% to 27% of cases in the literature (14,15). In our study, the incidence was 21.6%, aligning with previous reports. The depth of the lesion has been determined to be the most significant risk factor for hemorrhage (3). In our study, the mean lesion depth in patients who developed hemorrhage was 26.41 mm, compared to 10.71 mm in those who did not, highlighting a significant difference. To minimize the likelihood of pulmonary hemorrhage, it is recommended that patients be placed in the lateral decubitus position with the biopsy side facing down after the procedure (2). In our series, all hemorrhagic events resolved spontaneously without requiring additional intervention, and none were clinically severe.

Other rare but serious complications include systemic air embolism, pericardial tamponade, and hemothorax, which carry high morbidity and mortality and require a multidisciplinary approach. The mortality rate of such events has been reported to be below 1% in the literature (2). In our patient group, no cases of mortality or major complications were observed.

Study Limitations

This study has a number of limitations. First, its retrospective nature and the limited sample size may restrict the applicability of the findings. The lack of long-term follow-up and absence of surgical outcomes prevents definitive conclusions regarding final diagnoses. Although the procedures were performed at a single center by three different operators, all radiological assessments were conducted by the same radiologist. Cytological evaluations were also performed by the same cytopathologist, which may affect generalizability.

Additionally, because of the small sample size of patients with emphysema and the absence of variation in emphysema types, an objective scoring system such as the Goddard score could not be applied. Therefore, the likelihood of pneumothorax in patients with emphysema was presented independently of emphysema severity.

Conclusion

Our study demonstrates that TTFNAB, when performed by experienced operators with cytopathological support, is a safe diagnostic method with high accuracy and generally mild, manageable complications. Absence of pleural contact and increased pleural-lesion distance were associated with higher complication rates. TTFNAB remains a valuable tool in the clinical assessment of peripheral, high-risk, or bronchoscopically inaccessible lung lesions. Future research should involve larger patient populations and include prospective, randomized controlled trials. Repeating similar studies in different centers with different operators and cytopathologists would enhance generalizability and minimize potential biases.

Ethics

Ethics Committee Approval: The study was approved by the University of Health Sciences Türkiye, İstanbul Education and Research Hospital, Clinical Research Ethics Committee (approval number: 202, date: 17.06.2022).

Informed Consent: All participants provided informed consent.

Footnotes

Authorship Contributions: Surgical and Medical Practices - M.K., M.S.Ç., M.K., B.Ö., A.S.M.; Concept - M.K., M.S.Ç.; Design - M.K., M.S.Ç.; Data Collection or Processing - M.K., M.S.Ç.; Analysis or Interpretation – M.K., M.S.Ç.; Literature Search - M.K., M.S.Ç.; Writing – M.K.

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