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Computed tomography assisted transthoracic needle aspiration biopsy: 5 years experience*

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ABSTRACT

Aims: Transthoracic needle aspiration biopsy (TTNAB) is used to diagnose thoracic lesions and has a wide range of indications and few contraindications. The aims of this study were to assess the diagnostic value and complication rate of computed tomography-guided TTNAB for malignant diseases, to identify factors that influence diagnostic value and complication rate, and to compare our practices to those described in the literature.

Methods: A retrospective, observational, and cross-sectional study was designed to investigate the complication incidence and diagnostic value of the TTNAB. In Our study, 208 patients who underwent computed tomography-guided transthoracic needle aspiration biopsy at our hospital by pulmonologists between July 2007 and February 2013 were analyzed. In addition to descriptive statistical methods the Pearson Chi-square test was used to compare quantitative data when evaluating the study's data. The significance level of the results was accepted as $p<0.05$ with a 95% confidence interval.

Results: The ages of the patients ranged from 33 to 88 years and the 179 of them were male. The procedure's outcomes and rates of complications were documented. To evaluate the diagnostic value, we analyzed the clinical and radiologic follow-up results of 136 patients whose data were available. The rate of malignant diagnoses was 72.1%, while the rate of benign diagnoses was 4.4%. For malignant lung tumors, the sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of the procedure were calculated to be 80%, 93%, 99%, 37%, and 82%, respectively. The only observed complication was pneumothorax, which occurred in 8 of 208 patients (3.8%). Diagnostic value and complication rate were unaffected by lesion size and needle thickness.

Conclusion: According to the findings of this study, computed tomography-guided TTNAB procedures in the diagnosis of malignant thoracic lesions have good diagnostic accuracy and low complication rates, which is consistent with litreture.

Keywords: Tomography, needle, biopsy, sensitivity, lung neoplasms

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INTRODUCTION

Transthoracic needle aspiration biopsy (TTNAB) is a well-described and reliable procedure for diagnosing thoracic lesions.[1,2] TTNAB is commonly used to diagnose lung nodules and masses, mediastinal lesions and hilar lesions, chest wall invasion, infiltration, and consolidations.

TTNAB has 64-100% sensitivity for malignant disorders.[1,3-6] 12-68% specificity for benign diseases.[7-9] The most common procedure-related complication is pneumothorax, which occurs 8-64%.[10-13] Hemoptysis, hemorrhage, systemic air embolism, inlet line tumor cell growth, empyema, lung torsion, and pericardial tamponade are rare complications.[14,15]

It is essential to diagnose malignant disease with a minimally invasive method, such as TTNAB, in patients who cannot be evaluated further due to general condition disturbance, advanced age, or additional disease. In addition, the use of TTNAB for the diagnosis of benign tumors can prevent unnecessary surgical procedures. There is an extensive amount of literature that investigates the various aspects that impact the diagnostic efficacy of the TTNAB procedure. The objective of this study is to evaluate the complication incidence and diagnostic value of the TTNAB procedure performed by pulmonologists for the diagnosis of malignant diseases and also to examine the factors that may affect these parameters.

METHODS

Study Design

A retrospective, observational, and cross-sectional study was designed to investigate the complication incidence and diagnostic value of the TTNAB. CT-guided TTNAB patients at our hospital from July 2007 to February 2013 were retrospectively analyzed. According to the institutional protocol at the time, all biopsies had been performed under the supervision of two pulmonologists and informed consent had been obtained from all patients prior to the procedure. This

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study was approved by the Süreyyapaşa Chest Diseases and Thoracic Surgery Training and Research Hospital Scientific Researches Ethics Committee (Date: 27.02.2025, Decision No: 2024-44). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

Evaluation of Diagnostic Value

To determine diagnostic value, the outcomes of patient samples were classified as malignant, benign, or non-diagnostic. Malignant aspiration samples contained malignant or atypical cells that were highly suggestive of cancer. Pathological symptoms of benign diseases like tuberculosis and pneumonia were seen as benign consequences. Non-diagnostic biopsies were those in which enough tissue was extracted but only inflammatory cells were found in the cytology and benign disease could not be determined.

The results of the biopsy were compared to clinical follow-up, therapy response, and other diagnostic procedures. Patients with less than a year of follow-up or who were lost to follow-up were excluded from the analysis. Only 136 patients' follow-up data were available. 136 patient records were used to determine the number of patients diagnosed with true positive, false positive, true negative, and false negative. The flowchart for the study is shown in **Figure**.

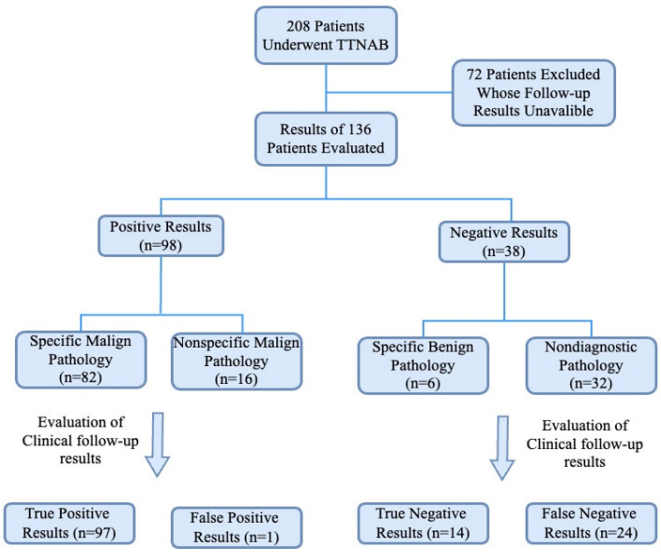

Figure. Flowchart of the study

To determine how lesion size affects diagnostic value, patients were divided into two groups. Lesions under 3 cm were in group one, whereas those 3 cm and over were in group two. The groups' sensitivity and diagnostic accuracy were assessed. Three groups (18-gauge, 20 gauge, and 22 gauge) were created based on needle thickness and tested for sensitivity and diagnostic accuracy.

Evaluation of Complications

We documented pneumothorax and other complications in patients on whom we performed biopsies. In the monitoring room, patients were observed after the procedure. One hour later, all patients had a control chest radiograph. Patients at high risk of pneumothorax had a second chest radiograph four hours later. To investigate the effect of lesion size on pneumothorax development, two groups were created based on lesion size. The large tumor group contained lesions measuring at least 3 centimeters in diameter, whereas the small tumor group contained lesions measuring less than 3 cm. The frequency of pneumothorax was determined and compared in groups with small and large tumors. Similarly, three groups were formed depending on the size of the biopsy needle: 18-, 20-, and 22-gauge, and pneumothorax rates were compared between these groups.

Statistical Analysis

SPSS (Statistical Package for Social Sciences) for Windows 17.0 was utilized for statistical analysis. Continuous variables were written based on their distribution. The mean and standard deviation were utilized to summarize data with a normal distribution. Those with non-normal distributions were represented by median and interquartile ratios (25%-75%). Using the Shapiro Wilk Test, the normality of distributions was analyzed. The dichotomous values were calculated as a number and a percentage value (%). In addition to descriptive statistical methods the Pearson Chi-square test was used to compare quantitative data when evaluating the study's data. The significance level of the results was accepted as $p<0.05$ with a 95% confidence interval.

RESULTS

CT-guided TTNAB was performed on 208 patients (86% male) from July 2007 to February 2013. The sample population has a median age of 62, ranging from 88 to 33. Seventy-two (34.6%) of 208 TTNAB patients were excluded due to lack of follow-up data. **Table 1** provides a detailed review of patient demographics, needle size distribution, lesion size, pathological findings, and complications in the TTNAB.

Table 1. TTIAB patient demographics, lesion size and needle size distribution, and complications

Age, median (25%-75%)	62 (53-69)
Male, n (%)	117 (86)
Lesion size, n (%)	
<3 cm	13 (10)
≥3 cm	123 (90)
Needle size, n (%)	
18-gauge	20 (15)
20-gauge	74 (54)
22-gauge	42 (31)
TTIAB pathology, n (%)	
Malign	98 (72)
Benign	6 (4)
Nondiagnostic	32 (24)
Malign pathological results of TTIAB, n (%)	
Non-small cell lung carcinoma	47 (49)
Squamous cell carcinoma	17 (17)
Adenocarcinoma	14 (14)
Small cell carcinoma	4 (4)
Nonspecific malignant cells	16 (16)
Benign pathological results of TTIAB, n (%)	
Tuberculosis granuloma	3 (50%)
Pneumonia	3 (50%)
Complications, n (%)	
Pneumothorax	8 (3.8)

TTIAB: Transthoracic needle aspiration biopsy

Although adequate material was obtained by aspiration, 32 (23.5%) of the biopsies were categorized as non-diagnostic. Because the pathology comprised of only inflammatory cells and these findings were insufficient for a definitive diagnosis of benign disease. After follow-up, 24 (75%) of these 32 patients had definite malignant disease identified by surgery, bronchoscopy, lymph node biopsy, or endobronchial ultrasound, and 8 (25%) had benign disease. **Table 2** shows 32 patients' final diagnosis. **Table 3** shows TTİAB's sensitivity, specificity, positive and negative predictive values, and diagnostic accuracy.

Table 2. Final diagnoses of non-diagnostic TTNAB

Final diagnoses	Diagnostic method	Total, n (%)
Malign		24
Adenocarcinoma	Surgery, lymph node biopsy	8 (33)
Squamous cell carcinoma	Surgery, bronchoscopy, endobronchial ultrasonography	7 (30)
Non-small cell lung cancer	Bronchoscopy, endobronchial ultrasonography, lymph node biopsy	3 (13)
Atypical carcinoid	Surgery	1 (4)
Large cell carcinoma	Surgery	1 (4)
Hodgkin lymphoma	Surgery	1 (4)
Mesothelioma	Surgery	1 (4)
Thymic carcinoma	Surgery	1 (4)
Solitary fibrous tumor	Surgery	1 (4)
Benign		8
Pneumonia	Surgery	3 (38)
Tuberculosis granuloma	Surgery	2 (25)
Granulomatous inflammation	Surgery, lymph node biopsy	2 (25)
Organized pneumonia	Surgery	1 (12)

TTIAB: Transthoracic needle aspiration biopsy

Table 3. Diagnostic value of transthoracic needle aspiration biopsy

	%	95% confidence interval upper-lower limit
Sensitivity	80	0.73-0.88
Specificity	93	0.80-1
Positive diagnostic value	99	0.97-1.00
Negative diagnostic value	37	0.21-0.53
Overall accuracy	82	0.75-0.89

To determine the factors influencing the diagnostic value, we calculated sensitivity and accuracy based on the size of the lesion and the thickness of the needle used in TTİAB procedure. **Table 4** presents a summary of the results.

Table 4. Diagnostic value of the TTIAB procedure according to lesion and needle size

Lesion size	Sensitivity (%)	Accuracy (%)
*<3cm	75	84.6
**≥3cm	80.5	81.3
Needle size		
18-gauge	77.8	80
20-gauge	87.5	87.8
22-gauge	69.2	71.4

*: Small tumor group, **: Large tumor group, TTIAB: Transthoracic needle aspiration biopsy

Between July 2007 and February 2013, 8 of the 208 patients who underwent TTNAB showed pneumothorax. One patient required a chest tube. The calculated rate of complications was 3.8%. The effect of lesion size and needle thickness on the rate of complications was analyzed in 136 patients for whom follow-up information was available. Lesions were divided into two groups: those measuring less than 3 centimeters and those measuring 3 cm or more. There was no statistically significant difference between the groups' incidence of complications. To examine the effect of needle thickness on pneumothorax rate, biopsy needles were divided into three groups according to gauge size (18-20-22). There was no difference in pneumothorax rate between the groups. Results are summarized in **Table 5**.

Table 5. Comparison of complication rates according to lesion and needle size

		Complication		p
		Yes, n (%)	No, n (%)	
Lesion size	<3cm	2 (15%)	11 (85%)	0.060
	≥3cm	6 (5%)	117 (95%)	
Needle size	18-gauge	0	32 (100%)	0.464
	20-gauge	5 (5%)	101 (95%)	
	22-gauge	3 (4%)	67 (96%)	

DISCUSSION

TTNAB is unusually complicated and safe procedure. Therefore, it is often used to diagnose thoracic lesions. It is less expensive and easier than thoracotomy and open lung biopsy.[16,17] CT-guided transthoracic needle aspiration biopsies for malignant lung tumors had 80% sensitivity and 82% accuracy in our investigation. The scientific literature reports that TTNAB's sensitivity for malignant illnesses ranges from 64 to 100%, but is usually 80-97%.[1,3-6] Diagnostic accuracy exceeds 97%.[18] Zhuang et al.[6] found 96.3% sensitivity and 96.1% diagnostic accuracy in 102 CT-guided TTNAB patients. Wallace et al.[11] demonstrated 82% sensitivity and 88% diagnostic accuracy using CT-guided TTNAB on 61 sub-1 cm lesions. Transthoracic sampling cannot always diagnose benign lesions. Solak et al.[4] found 34% of 102 USG-guided TTNAB cases benign. This rate is 31%, per McSweeney et al.[19] After the study's follow-up, 13 patients were diagnosed with benign illness, however TTNAB only identified six of them.

The results of our TTNAB are consistent with the findings reported in the literature for both malignant and benign diagnoses. The absence of a cytopathologist during TTNAB may have decreased sensitivity and diagnostic accuracy by raising our inappropriate sampling rate. Other studies show that pathologists improve diagnosis accuracy.[3,20-22] The non-diagnostic rate for TTNAB ranged from 5.5% to 29% in various studies.[23-26] Our study had 23.5%. Malignant diagnosis in the follow-up of non-diagnostic TTNAB results was 100% in one research, but it normally ranges from 33 to 73%.[19,23-26] Our 32 patients had non-diagnostic TTNAB results. 24 had malignant disease throughout follow-up, while 8 had benign disease. False-negative cases were calculated at 17.7%. According to a study, false-negative cases should be around 10%.[21] False negatives often come from insufficient sampling. Inflammation, fibrosis, and tumor necrosis around a malignant nodule may prevent adequate sampling.[4]

One of the elements influencing TTNAB's diagnostic value is the size of the lesion. There is inconsistency in the terminology used to define large tumor groups and small tumor groups in studies investigating this topic. To provide a consistent approach, the investigation border was set at 3 cm, considering the definition of a solitary pulmonary nodule in our study. While sensitivity is higher in the group with large tumors, the overall accuracy rate is greater in the group with small tumors. This could be due to the lower false-negative rate observed in the group with the largest tumors. Various studies in the literature present different results regarding the relationship between lesion size and the diagnostic value of TTNAB.[6,11,25,27] Furthermore, these studies differ in terms of the imaging methodologies and needle diameters used. This could also alter the diagnostic value.

Another factor influencing the diagnostic value of TTNAB is the size of the biopsy needle. A study compared 18 gauge (n=324) and 19 gauge (n=527) coaxial systems to investigate the effect of needle size on the diagnostic value of TTNAB.[12] In the 18-gauge group, both sensitivity and diagnostic accuracy were 96%, whereas in the 19-gauge group, sensitivity was 89% and diagnostic accuracy was 92%. The authors state that these ratios are comparable. In our analysis, we compared 18-, 20-, and 22-gauge single aspiration needles. The 20-gauge group's calculated sensitivity and diagnostic accuracy were greater than those of the other groups. Due to the heterogeneity of the groups in terms of the type and extent of lesions treated by the procedure, it is difficult to interpret this result.

Pneumothorax remains the most prevalent complication associated with TTNAB.[15,28-31] According to various studies, the incidence of pneumothorax ranges from 8% to 64%, and the proportion of pneumothorax cases requiring a chest tube ranges from 3.3% to 15%.[32,33] In our investigation, eight out of 208 patients who underwent TTNAB developed pneumothorax. 3.8% was the calculated pneumothorax rate. Only one patient (0.4%) required a tube thoracostomy to manage pneumothorax.

Similar to our findings, Salepci et al.[3] observed 3.5% pneumothorax. This study used computed tomography (CT) immediately after the surgery to evaluate all individuals for pneumothorax, but chest radiography was performed only 5 to 6 hours later in high-risk cases. In our study, all patients who underwent CT evaluation following the procedure also received a chest radiograph one hour later. Patients with a high probability of pneumothorax were the only ones who received repeat chest radiographs four hours later. Consequently, it is possible that some patients were not evaluated for late-onset pneumothorax. Our pneumothorax rate is lower than the literature's, consistent with Salepci et al. study. Age, gender, lesion distance from the pleural surface, emphysema, smoking history, sampling method (aspiration needle, cutting needle), number of passages through the pleura, operator experience, and patient compliance all affect pneumothorax risk. Many research have addressed these variables in the literature.[12,30,34]

Lesion size and needle thickness in pneumothorax were one of our objectives. We divided needles into three groups to determine how needle thickness affected pneumothorax rate. Pneumothorax rates were not significantly different across 18-, 20-, and 22-gauge groups.

In 846 patients, Geraghty et al.[12] found that the 19-gauge needle group had a 50% lower pneumothorax rate than the 18-gauge group. Age, gender, lesion size, and cutting system did not affect the this statistically significant outcome.In 102 patients, Zuanq et al.[6] reported no statistically significant difference in pneumothorax rates between 18-gauge and 20-gauge aspiration needles. Shaukat et al.[35] observed no difference in pneumothorax incidence with 18-, 20-, and 22-gauge aspiration needles in a trial like ours.

Studies have also examined lesion size as a factor influencing the pneumothorax rate. Laurent et al.[31] found 15% pneumothorax in 67 patients with 2 cm lesions and 16% in 135 individuals with >2 cm lesions. There was no statistically significant difference in pneumothorax incidence between groups. Yeow et al.[34] observed a statistically significant association between lesion size and pneumothorax rate, showing that decreased lesion size increased pneumothorax rate. The same study found that experience can lower pneumothorax risk up to a 2 cm critical lesion while performing a routine biopsy. In this investigation, the pneumothorax rate in the 2 cm lesion group was independent of operation experience, however it reduced as procedure experience increases. The effect of lesion size on pneumothorax rate is uncertain, however our study demonstrated no statistically significant difference between groups with lesion diameters less than 3 cm and higher than 3 cm. Since the same team performed all study activities, we believe our findings are independent of practitioner experience.

Paranchymal hemorrhage is the second most common TTNAB complication.[36] No TTNAB procedures in our sample had hemorrhage or rare complications like systemic air embolism, tumor cell spread along the entry line, empyema, lung torsion, or pericardial tamponade.

Recent studies continue to affirm the diagnostic efficacy and safety profile of CT-guided TTNAB. For instance, a 2023 study reported a diagnostic accuracy exceeding 90% for TTNAB in peripheral lung lesions, highlighting its reliability in clinical practice. Moreover, the incidence of pneumothorax, the most common complication associated with TTNAB, has been reported to range between 9% and 54%, with an average around 20%. These findings underscore the importance of meticulous technique and patient selection to minimize complications. Our study's results align with these recent findings, reinforcing the role of CT-guided TTNAB as a valuable diagnostic tool in thoracic oncology.[37,38]

Limitations

However, it is essential to recognize the limitations of our investigation. Due to the retrospective character of the study, there may be missing data. Second, the extent of the group of patients with small tumors was minuscule. Although we examined the effect of lesion size and needle thickness on the complication rate and diagnostic value, we did not take into account other variables, including age, gender, distance of the lesion from the pleural surface, sampling procedure, number of pleural passages, and patient compliance. These variables may also play an important role, but they were excluded from our analysis. As detailed in the discussion section, two further significant limitations of our study are the absence of a cytopathologist during the TTIAB procedure and the failure to evaluate the patients in terms of late pneumothorax. TTNAB without a cytopathologist may increase improper sampling and lower sensitivity and diagnostic accuracy.

Failure to evaluate late pneumothorax may have biased the complication rate.

CONCLUSION

This study demonstrates that CT-guided TTNAB can diagnose lung tumors, especially malignant ones, quickly and accurately. Lesion and needle size did not affect TTNAB complications. Our research demonstrated that TTNAB is a safe procedure and that its diagnostic efficacy is consistent with the literature. Further research is needed to better understand the impact of lesion size, imaging techniques, and needle sizes on the diagnostic value of TTNAB.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was carried out with the permission of the Süreyyapaşa Chest Diseases and Thoracic Surgery Training and Research Hospital Scientific Researches Ethics Committee (Date: 27.02.2025, Decision No: 2024-44).

Informed Consent

Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

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Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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