SJIF Impact Factor: 6.711

WORLD JOURNAL OF ADVANCE HEALTHCARE RESEARCH

ISSN: 2457-0400
Volume: 9.
Issue: 10
Page N. 124-131
Year: 2025

Original Article ww.wjahr.com

DIAGNOSTIC ACCURACY AND COMPLICATION RATES OF TRANSTHORACIC CT-GUIDED NON-COAXIAL NEEDLE BIOPSY OF PULMONARY LESIONS

Sabruldeen M. Mohammad*[1], Omer Muthaffare Towfeque[2]

[1]Oncology and Nuclear Medicine Hospital, Nineveh Health Directorate, Mosul, Iraq.
[2]Research Teaching Hospital, Nineveh Health Directorate, Mosul, Iraq.

Article Received date: 29 July 2025 **Article Revised date:** 19 August 2025 **Article Accepted date:** 08 September 2025

***Corresponding Author: Sabruldeen M. Mohammad**
Oncology and Nuclear Medicine Hospital, Nineveh Health Directorate, Mosul, Iraq.
DOI: https://doi.org/10.5281/zenodo.17223785

ABSTRACT

Background: Computed tomography (CT)-guided transthoracic needle biopsy is a well-established method for the diagnosis of various intrapulmonary lesions, with two types of biopsy techniques employed, fine-needle aspiration biopsy (FNAB) and core biopsy (CB). Besides the needle type, other factors such as lesion size, nature of the lesion, experience and skills of interventional radiologist influence the diagnostic accuracy. **Objectives:** aim to assess the diagnostic accuracy and complication rates of transthoracic CT-guided non-coaxial core biopsies of intrapulmonary lesions classified by lesion size into group (A) <35 mm, (B) 35–50 mm, and (C) >50 mm lesions. **Methods:** Over a 2-year period, 120 lung biopsies were performed using the non-coaxial biopsy technique with 18G semi-automated true-cut needle. There were 80 (66.40%) male and 40(33.60%) female patients, with a mean age of 64.01±9.18 years (18–85 years). The mean lesion size was 59.6±29.3 mm. The lesions were classified into three groups according to size: group (A) lesion <35 mm (n=25, 20.5%), group (B) lesions 35–50 mm (n=35, 29.5%), and group (C)lesions >50 mm (n=60, 50%). Diagnostic accuracy, sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) were calculated for all biopsies, and for each group separately, as well as the incidence of complications. **Results:** The overall diagnostic accuracy was 91%, with 95.3% sensitivity, 100% specificity, 100% PPV, and 41.6% NPV. For group (A) lesions <35 mm, diagnostic accuracy, sensitivity, and PPV were 100%. The lowest diagnostic accuracy was 85% in lesions >50 mm, with 92.4% sensitivity, 100% specificity, 100% PPV, and 33.3% NPV. An adequate sample was obtained in 111 core biopsies (92.5%), while 9 biopsies (7.5%) were nondiagnostic due to necrosis (5%) and insufficient biopsy material (2.55%). minor pneumothorax is most frequent complication which was occurred in 18.5%; major pneumothorax requiring chest tube occurred in 4 patients (3.3%). **Conclusion:** the diagnostic accuracy decreased with increasing lesion size. On the other hand, complication rates were higher in smaller lesions group (A), and those more pleural distance from the lesion.

KEYWORDS: Accurate, Diagnosis, Lung, Mosul, Nodule.

INTRODUCTION

Computed tomography (CT)-guided transthoracic needle biopsy is a well-established method for the diagnosis of different intrapulmonary suspected tumors, with 2 types of biopsy techniques employed, fine-needle aspiration biopsy (FNAB) and core biopsy (CB). High diagnosis accuracy for lung cancers is achieved by both techniques, from 89% in FNAB to 91% in CB.[1] Non-Coaxial biopsy technique has a reported overall diagnostic accuracy for both benign and malignant lung lesions with range between 82.5% to 95%.[2-4]

Besides the needle type, other factors such as lesion size, nature of the lesion, experience and skills of interventional radiologist influence the diagnostic accuracy. Lesion size ≤1 cm is reported as a significant risk factor decreasing diagnostic accuracy, but in published data lesions >5 cm and even ≥3.1 cm, are also identified as factors that decrease the diagnostic accuracy because of necrotic tissue content mainly.[4-5]

Minor pneumothorax is the most frequent problem following lung biopsies, occurring in 18.5% of cases for CB.[6]

This retrospective study aimed to assess the diagnostic accuracy and complication rates of transthoracic CT-guided non-coaxial lung biopsies of intrapulmonary lesions classified by lesion size into group (A) <35 mm, (B) 35–50 mm, and (C) >50 mm lesions.

MATERIAL AND METHOD

The study was started from the 1st of March 2023 to the end of January 2025, it included 120 patients for which 120 biopsies was done. Before the procedure took place, all patients provided informed consent, and the institutional ethics committee / Nineveh health directorate approved the study (series number 2025159/34101 on 7/8/2025).

Patients with lung lesions whose CT or PET-CT scans verified the existence of a lung mass for which a biopsy procedure was performed were included in the study. Moreover, all of the included patients provide written pathologic report, and relevant clinical data in the privet clinic such as surgical report, received therapy, post biopsy imaging. Furthermore, all of the included patients had international normalized ratio (INR) equal to or <1.5 and platelet count (>50,000). The study excluded patients whose lost follow-up were visiting. Uncooperative patients, pregnancy, vascular lesion (AV Malformation), bullous emphysema, partial treated TB, pulmonary hypertension or those with severe respiratory, heart, renal, liver failure and uncorrectable coagulopathy were considered non-eligible for biopsy.

Before the biopsy procedure, spirometry was done as part of the patient's routine clinical examination. For lesion assessment and biopsy route planning, previous non-contrast (native) and contrast-enhanced CT images were obtained for every patient. Few patients had PET scan before biopsy All biopsies were performed with aid of a 64-slice MDCT (BRILLIANCE 190P/64 PHILIPS). By using a 18G non-coaxial true-cut semi-automatic needle-biopsy and all biopsies were performed by interventional radiologists who have[7] year experience in lung biopsies.

A quality threshold was set, and complications were categorized as minor and major in accordance with the CIRSE and SIR guidelines for percutaneous needle biopsies.[7,8]

Biopsy Procedure

In most cases, the shortest distance between the pleura and the lesion was selected, the path of needle and patient's position were set based on the CT scan results. Seventy-two patients (60.4%) had biopsies done in a prone position, forty-two (35%) in a supine position, and six (5%) in a lateral decubitus position. The entrance point was identified, assessed, and marked on the skin following an initial scan of the chosen region with 2.5 mm slice thickness. Then povidone-iodine and covered with sterile drapes was used for cleaning. The skin and subcutaneous tissue of the chest wall were injected with 5 mL of 2% lidocaine as a local anesthetic.

With No. 11 scalpel we make a small incision on the skin. All of the patients were instructed to hold their breath and not cough before the needle was inserted. In each biopsy, only 1-2 pleural entries were performed; 1-3 samples were obtained and placed in a 10% formalin solution for pathologic analysis.[9] Due to significant pneumothorax during the procedure, only one biopsy sample were taken from four patients and (2) biopsy samples in two patients. Immediately after the biopsies, CT scans were performed, and a follow-up chest X-ray was planned for two to four hours later to check for any complications. Thoracic surgeons placed a chest tube to drain patients with pneumothorax greater than 50% of the hemithorax, and the patients stayed in the hospital until they recovered. All patients were monitored for 24 hours following the procedure, and those with mild complications received conservative treatment.

Data collection and statistical analysis

Total number and percentage were used to present lesion size, complication, sample adequacy, and compatibility, whereas mean and standard deviation were used to present the distance between the lesion and pleura. To find out how these factors affected the accuracy of the diagnosis, statistical tests were carried out. For independent samples, possible differences were assessed using the chi-square test, Fisher's exact test, and Mann-Whitney U test. The statistical significance was defined at $p < 0.05$. The diagnostic accuracy was calculated in terms of sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy, both for the entire sample and for each group of lesions.

RESULTS

The study included 120 patients, with 80 males (66.4%) and 40 females (33.6%). The mean age of the study patients was 64.01±9.18 years (range: 17-84). The lesions were classified into three categories: (A) < 35 mm, (B) 35-50 mm, and (C) > 50 mm. The lesion size ranged from 13 mm to 191 mm, with an average of 59.6 ± 29.3 mm. The distance from the pleura to the closest boundary of the lesion was 10.8±13.5 mm, and the interlobar fissure was transgressed in three patients (2.5%). Statistically significant difference found between males and females regarding their distribution of lesion size ($p = 0.0001$). Males tended to have bigger lesions. There were 48.8% male and 51.2% female patients in group (A), 60.4% male and 39.6% female in group (B), and 78.8% male and 21.3% female in group (C).

In one hundred and eleven biopsies (92.5%), sufficient samples were collected, whereas 9 biopsies (7.5%) were nondiagnostic. Generally, 99 (89%) of the biopsies diagnosed as malignant tumors, with adenocarcinoma being the most common primary lung cancer. The distribution of the study participants according to their biopsies' adequacy depending on their lesion size was shown in table 1. Two biopsies (8%) in the first group (A) were nondiagnostic; one was because of necrosis, and the other was because there was insufficient tissue for a pathological diagnosis. Two patients (5.7%) in the second group (B) had nondiagnostic tissue due to necrosis. Five biopsies (8.3%) in group (C) were non-diagnostic; three of the samples were necrotic, and two were insufficient for diagnosis.

Table 1: Distribution of the study participants according to their biopsies' adequacy depending on their lesion size in 120 lung biopsies.

□2= 0.23 p = 0.89			**Adequacy of sample**		**Total number**
			Adequate	**Nondiagnostic**	
Lesion size	Group(A) <35 mm	N	23	2	25
		%	92	8	100.0
	Group(B) 35–50 mm	N	33	2	35
		%	94.3	5.7	100.0
	Group(C) >50 mm	N	55	5	60
		%	91.7	8.3	100.0
Total		N	111	9	120
		%	92.5	7.5	100.0
□2, result of the chi-square test.					

The study found necrotic tissues in each of the three lesion groups, but there was no statistically significant difference between them. Based on the sample of 111 biopsies, the following statistics parameters were computed: sensitivity, specificity, PPV, NPV and diagnostic accuracy. In 30 patients, the final diagnosis was verified by surgery (25%), and in 90 patients, it was confirmed by imaging and the clinical outcome of the condition (75%). The follow up CT scans of these individuals have revealed the presence of metastatic or pulmonary infiltration cancer, occasionally the regression or no disease progression following chemotherapy, or the full remission of benign inflammatory conditions following drug therapy. As shown in table 2 and table 3.

Table 2: The Diagnostic Accuracy, Sensitivity, Specificity, PPV, and NPV In A Total Of 120 Core Biopsies.

		Lesion size group		
	Group (A) <35 mm	**Group (B) 35–50 mm**	**Group(C) >50 mm**	**Total**
Sensitivity, %	100	93.5	92.4	95.3
Specificity, %	100-	100	100	100
PPV, %	100	100	100	100
NPV, %	-	50	33.3	41.6
Diagnostic accuracy, %	100	88.5	85	91
PPV, positive predictive value; NPV, negative predictive value.				

Table 3: The effect of lesion size on the true positive, false negative and true negative results in 111 biopsies.

χ2= 3.27 p = 0.52			**Lesion size groups**			
			Group(A) <35 mm	**Group(B) 35–50 mm**	**Group(C) >50 mm**	**Total**
Accuracy	True positive	N	23	29	49	101
		%	100.0	87.8	89	90.9
	False negative	N	0	2	4	6
		%	0.0	6.0	7.2	5.4
	True negative	N	0	2	2	4
		%	0.0	6.0	3.6	3.6
Total		N	23	33	55	111
		%	100.0	100.0	100.0	100.0
χ2, result of the chi-square test.						

Overall, 28 patients experienced complications, with a 23.3% complication rate. Minor pneumothorax was the commonest complication, which occurred in 22 (18.5%) patients (Figure 1). The need for chest tube for major pneumothorax happened in four (3.3%) patients, with a mean catheter dwelling time of 8days. The other complication that occurred was minor parenchymal hemorrhage, which occurred in 1.5% of patients. Regarding the patient's age or gender, position, and operator experience, there was not a significant difference in the rates of complications. The interlobar fissure was transgressed only in three biopsies, without complication.

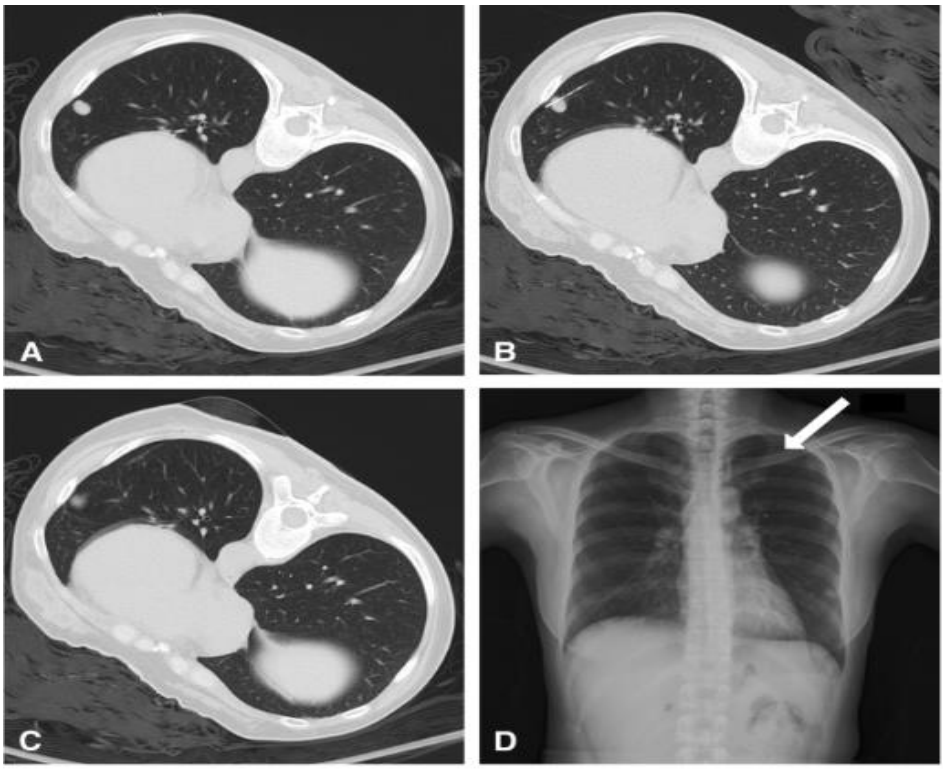

Figure 1: A lung biopsy performed on a 44-year-old woman under CT guidance. A 10-mm nodule above the left lower lobe was discovered by pre-biopsy CT.

B. An 18-gauge cutting needle was used for the biopsy procedure. A suitable entrance point was selected to keep the needle from passing through the fissure and being trapped by the rib. The needle's cutting notch was finally positioned just inside the nodule.

C. A CT scan after the biopsy showed a little amount of lung hemorrhage surrounding the needle path. D. A standing X-ray of the chest was taken 24 hours following the procedure. Pneumothorax over the left side was confirmed, and the pleural line (arrow) over the left upper chest was apparent.

Table 4: Analysis of the influence of the lesion size and distance of the lesion from pleura on the occurrence of complications in a total of 120 core biopsies.

Complication					
			No	**Yes**	**p**
Lesion size	Group (A) < 35 mm	n	14	11	□2= 9.42 p = 0.009
		%	56	44	
	Group (B) 35–50 mm	n	26	9	
		%	74.3	25.7	
	Group (C) >50 mm	n	52	8	
		%	86.7	13.3	
Pleural distance from the lesion (mm)		Mean	8.44	19.16	U= 5.353 p = 0.0001
		SD	2.78	7.05	
SD, standard deviation; □2, result of the chi-square test; U, result of the Mann–Whitney U test					

According to our study, emphysema did not independently increase the incidence of parenchymal bleeding or pneumothorax. Lesion size, distance from the pleura, needle gauge, frequency of pleural punctures, and patient posture were the only five parameters that we identified to have an impact on the incidence of problems. Table 4 lists the two most significant variables that affected the occurrence of complications. It is evidence that there was no statistically significant difference in getting enough tissue (p > 0.05).

The highest complication rate (44%) was in group (A)lesions <35 mm, which was statistically significant (p = 0.009). The lowest complication rate (13,3%) was in group (C) lesions >50 mm. The distance of the lesion from the pleura of 19.16 mm was also statistically significant (p = 0.0001). These two factors were related, as the larger lesions were less distanced from the pleura than the smaller one (Figure 2).

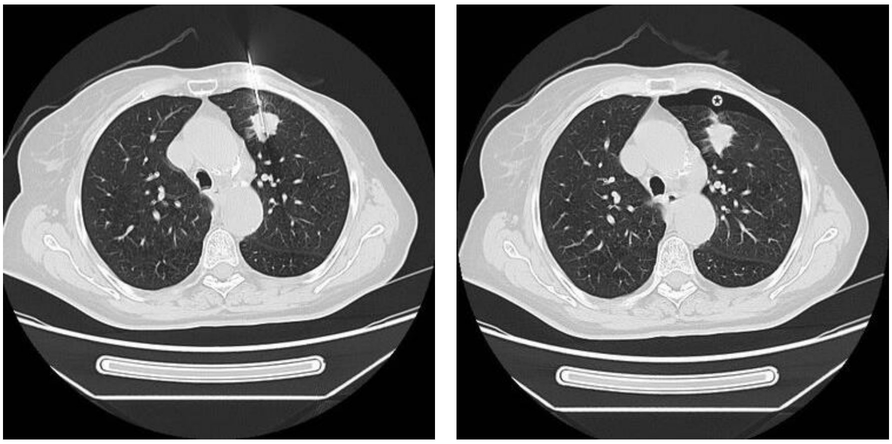

Figure 2: Axial CT scan (a) reveals the needle point in a solid lesion in the upper left lung lobe. A small pneumothorax is visible on the non-contrast CT scan (b) (white encircled by black stars).

DISCUSSION

In our study, the overall diagnosis accuracy was 91%, with 95.3% sensitivity, 100% specificity, 100% PPV, and 41.6% negative predictive value. Our findings were consistent with earlier studies that evaluating the diagnostic accuracy of the non-coaxial core biopsy technique.[4, 10, 11]

The sensitivity, PPV and diagnostic accuracy for group (A) were 100% respectively. While some studies revealed high diagnosis rates for lesions under 2 cm, others found that small lesion size is affecting the diagnostic accuracy.[3,4,5,12,13] Because we had only five lesions smaller than 2 cm, our results are not entirely comparable to those of prior studies.

For group (B) lesions, the diagnostic accuracy, sensitivity, and specificity were 88.5%, 93.5%, and 100%; for group (C) lesions, the corresponding values were 85%, 92.4%, and 100%. Perilesional inflammatory tissue around the tumor was the cause of six false negative findings (5.4%) in these two groups. There was no significant difference regarding the presence of tissue necrosis between the three groups. Necrotic tissue from big tumors was more easily distinguished from viable tumor tissue on native (non-contrast) and contrast-enhanced CT images during pre-biopsy planning than tumor tissue from condensed lung tissue and perilesional pneumonitis. According to Yeow et al.[4] and Hiraki et al.[5] lesions >50 mm and ≥31 mm respectively were independent risk factors for diagnostic failure.

Nine patients (7.5%) had biopsy tissue that was insufficient for pathologic examination. Previous literatures showed that taking three samples is the best way to increase diagnostic accuracy and lower the risk of complications. Due to a pneumothorax that happened during the procedure, six patients in our study had less than three samples obtained; four patients(1.7%) had samples insufficient for histopathological diagnosis, and two patients had a specific final diagnosis of malignancy confirmed. Despite taking three samples, the biopsy tissues from the two remaining patients was insufficient for a precise pathological diagnosis. We found that our findings are consistent with those reported by Wehrshuetz et al.[9]

The study found, ninety-nine biopsies (89.1%) resulted in a definite diagnosis of malignant tumors, and eighty-three percent indicated carcinoma subtypes. Non-small cell lung carcinoma was the dominant type. Which runs with previous study found that adenocarcinoma was the most prevalent subtype of primary lung malignancies and was often found at the periphery.[14]

Our study's total complication rate was 23.3%, with mild pneumothorax being the most common adverse consequence. A small intrapulmonary bleeding was the other minor complication that happened. Complication rates were assessed in relation to the patient's sex, age and underlying emphysema, interlobar fissure transgression, operator experience, lesion size, depth, and location. As reported by other researchs, we determined that the lesion size and the distance between the lesion and the pleura were significant risk factors according to statistical tests (chi-square and Mann

Whitney U).[15,16]

In our study, pneumothorax needing drainage was the most important major complication, occurring in 4 patients (3.3%). Compared to previous studies that also employed 18G core biopsy needles, our complication rates were lower.[3,15,17] Hemostasis, hemothorax, air embolism, and mortality are among the other serious complications that have been described but did not occur in our study.

The duration of catheter dwelling was extended for all four patients with significant pneumothorax (4–15 days). Only three biopsies in our sample had interlobar fissure transgression without any complications, despite Moreland et al.[18] reporting it as an independent risk factor for prolonged pneumothorax drainage. We did not prove that emphysema is a risk factor for problems on its own, although three of the patients who experienced pneumothorax had underlying emphysema. Laurent et al.[16] found that an older age group and emphysema were independent variables associated with a greater percentage of significant pneumothoraxes that required drainage, and Takeshita et al.[3] proved that supine position of the patient, longer needle path, small size lesion, lower lobe lesion location, multiple pleural punctures, and patient with obstructive lung function test as risk factors for pneumothorax.

Intrapulmonary hemorrhage was the second complication occurrence with a rate (1.5%), and it was self-limiting, not requiring any further medical treatment.[19] Some risk factors for higher grade intrapulmonary hemorrhage, reported in the literature, are female sex, older age, emphysema, coaxial biopsy technique, supine position, longer needle path, non-restrictive lung function test, non-pleural contact, lesions <3 cm, lower lobe lesion and deeper location of the lesion.[21,22] Our complication rates were consistent with CIRSE guidelines for percutaneous needle biopsy and SIR recommendations for the quality improvement threshold.[7,8]

Some factors can decrease pneumothorax occurrence rate are reported in the literature, are using coaxial needle to reduce multiple pleural punctures, prevent crossing fissures, bullae or blebs, proper patient selection, using blood patch or special Glu to close needle path after removal of needle.[31]

Table 5: demonstrates the diagnosis accuracy of small lung nodules utilizing CT-guided biopsy techniques in earlier studies.

Authors	No.of biopsies	Gauge (G) of the needles	Lesion size (mm)	Diagnostic accuracy (%)
Westcott et al. (26)	63	20-G aspiration needles	≦ 15	95.3
Laurent et al. (27)	67	19-G guiding needles and 20-G cutting needle	< 20	91
Tsukada et al(2)	72	18-G guiding needles and 19-G cutting needle	≦20	76.4
Wallace et al. (28)	61	18-G guiding needles and 20- to 22-G aspiration needles	≦ 10	87.7
Hiraki et al. (5)	795	19-G guiding needles and 20-G cutting needles	< 30	95.8
Lu et al. (29)	52	19-G guiding needles and 20-G cutting needles	≦30	94
Choi et al. (23)	305	20-G cutting or aspiration needles	<10	95
Li et al.(25)	169	19-G guiding needles and 20-G cutting needle	≦20	93.5
Tian et al. (30)	560	17-G guiding needles and 18-G cutting needles	≦ 30	94.6
(Present study)	120	17-G guiding needles and 18-G cutting needles	≦ 15	91

G gauge

The diagnostic accuracy of the overall biopsies was 91 %. Previous studies revealed accuracies for small nodules that ranged from 76.4 % to 95.8 %. The accuracies for smaller lung nodules in previous studies are summarized in Table 5. The high variability may be attributed to several factors, including patient selection, experience of the performer, presence or absence of a bed-side pathologist, and biopsy tools selection.

Westcott et al.[26] performed CT-guided aspiration using 20-gauge slotted needles on lesions less than or equal to 15 mm and found an accuracy of 95.3 %. This high accuracy may be partially attributed to the presence of a bed-side pathologist.

Wallace et al.[28] found an accuracy of 87.7 % in 61 patients with small lung nodules less than or equal to 10mm. However, 57 of the 61 patients had pre-existing primary malignancy.

Kothary et al.[24] performed CT-guided biopsies using 19-gauge guiding needles and 20-gauge biopsy guns on 37 patients with lesions equal to or smaller than 15 mm and found an overall accuracy of 51.4%. The cause of the low accuracy rate was attributed to the benign tendency of small nodules in their study. Pathologists have a more difficult time making a definitive diagnosis when the sample is benign.

Choi et al.[23] performed CT-guided biopsies using aspirations or core biopsies on 305 lesions smaller than 10 mm and found an accuracy of 95 %. The study was reviewed, and just 229 of the 305 lesions had a definite correct tissue diagnosis.

Hiraki et al.[5] performed CT fluoroscopy-guided biopsies using a 19-gauge introducer needle and 20-gauge automated cutting biopsy needle on 1000 lesions. A total of 795 of the 1000 lesions were less than 30 mm.

The diagnostic accuracy of the 795 lesions was 95.8 %.

The present study found an accuracy of 91%. This accuracy is not very high, but acceptable in the absence of an on-site pathologist, and many of the patients had no known history of malignant disease.

Some studies compared the accuracy of small and larger nodules and found significant difference in accuracy. The present study revealed a significant difference in accuracy, and the cause of this difference was quite straightforward. The smaller the nodule, the more difficult it is to obtain adequate tissue for pathological analysis.

Laurent et al.[27] compared nodules equal to or less than 20 mm with nodules larger than 20 mm. The diagnostic accuracies were 91 % and 96.2 % for small and larger nodules, respectively. No significant difference was found. This result may be attributed to the well-experienced performers and on-site pathologists, which helped achieve these high accuracy rates.

The study's limitation is its retrospective design, which may have introduced some unintended bias. Lesions less than 35 mm, particularly those smaller than 20 mm, were few. Because many of our patients were inoperable, the ultimate diagnosis was made based on control CT findings, response to medical oncologic therapy, or disease progression.

CONCLUSION

According to our study, complication rates and diagnostic accuracy were influenced by lesion size and pleural distance from the lesion. Lesions larger than 50 mm in group (C) had the lowest diagnostic accuracy and NPV, at 85% and 33.3%, respectively. The primary cause of false negative findings and diagnostic failure in group (C) lesions larger than 50 mm was perilesional inflammation. When it came to identifying necrotic areas in big tumors and planning biopsy, pre-biopsy examination of contrast-enhanced CT images was extremely sensitive. Lesions that were smaller farther away from the pleura had greater risks of complications; mild pneumothorax was the most common complication.

Conflict of Interest Disclosure: The authors declared no conflicts of interest

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