Ultrasound-Guided Pleural Needle Biopsy Which Needle for Which Patient: A Prospective Randomized Study

Emre Çelik[1], Muzaffer Metintaş[1,2], Güntülü Ak[1,2], Hüseyin Yıldırım[1], Emine Dündar[3], Nevin Aydın[4], Selma Metintaş[5,2]

[1]Department of Chest Diseases, Eskişehir Osmangazi University Faculty of Medicine, Eskişehir, Türkiye
[2]Lung and Pleural Cancers Research and Clinical Center, Eskişehir Osmangazi University, Eskişehir, Türkiye
[3]Department of Pathology, Eskişehir Osmangazi University Faculty of Medicine, Eskişehir, Türkiye
[4]Department of Radiology, Eskişehir Osmangazi University Faculty of Medicine, Eskişehir, Türkiye
[5]Department of Public Health, Eskişehir Osmangazi University Faculty of Medicine, Eskişehir, Türkiye

Background: Given the growing incidence of pleural effusions and the limited availability of medical thoracoscopy (MT) in clinical practice, ultrasound (US)-guided pleural needle biopsies using Abrams or cutting needles are increasingly being used for the histopathological diagnosis of pleural diseases.

Aims: To assessed the diagnostic yield and safety of US-guided Abrams and cutting needles to determine the optimal needle type for specific clinical situations.

Study Design: Prospective randomized study.

Methods: The study included 174 patients with undiagnosed pleural effusion requiring histopathological evaluation. Patients were randomized into two arms: those who underwent US-guided cutting needle biopsy (US-CNPB) and those who underwent US-guided Abrams needle biopsy (US-ANPB).

Results: The US-CNPB group exhibited a false-negative rate of 36.9% and diagnostic accuracy of 63.0%. compared to 21.3% and 78.7% in the US-ANPB group, with significant differences between the groups (p = 0.036 and 0.045, respectively). In patients with pleural thickening < 1 cm or absent on US, US-CNPB exhibited 55.2% diagnostic accuracy and a negative likelihood ratio (-LR) of 0.57. For US-ANPB, the corresponding rates were 77.3% and 0.32. The difference in diagnostic accuracy between the two groups was significant (p = 0.009). In patients with pleural thickening ≥ 1 cm, the diagnostic accuracy of US-CNPB was 93.3% and 88.9% for US-ANPB, with no significant difference between the groups. The corresponding -LR values were 0.08 and 0.17. In patients with pleural thickening < 1 cm, four major bleeding events (6.9%) occurred in the US-CNPB group. No deaths were reported in this study.

Conclusion: US-CNPB should be preferred in patients with pleural thickness ≥ 1 cm on US. MT is recommended for patients with pleural thickening < 1 cm or those presenting with pleural effusion without pleural thickening. However, in the absence of MT, US-ANPB is the preferred alternative because of its superior diagnostic accuracy and procedural safety.

INTRODUCTION

The overall estimated global incidence of pleural diseases is increasing. However, despite the availability of multiple diagnostic modalities, including cytologic examination following thoracentesis, a significant proportion of pleural diseases remain undiagnosed; therefore, histopathologic examination of pleural tissue samples is often necessary for definitive diagnosis.[1,2] Although medical thoracoscopy (MT) is the gold standard for diagnosing pleural diseases requiring tissue sampling due to its high diagnostic yield, it remains unavailable in many clinical settings. Image-guided pleural needle biopsy demonstrates a high diagnostic yield and may, therefore, serve as the first choice for tissue sampling in many clinics and patient populations.[2-4]

Corresponding author: Muzaffer Metintaş, Department of Chest Diseases, Eskişehir Osmangazi University Faculty of Medicine; Lung and Pleural Cancers Clinical and Reserach Center, Eskişehir Osmangazi University, Eskişehir, Türkiye

e-mail: muzaffermetintas@gmail.com

Received: April 21, 2025 **Accepted:** June 23, 2025 **Available Online Date:** 01.07.2025 • **DOI:** 10.4274/balkanmedj.galenos.2025.2025-4-90

Available at www.balkanmedicaljournal.org

ORCID iDs of the authors: E.Ç. 0000-0002-4675-1905; M.M. 0000-0002-4812-0170; G.A. 0000-0001-8849-193X; H.Y. 0000-0003-3011-0588; E.D. 0000-0002-9341-6579; N.A. 0000-0002-7765-4323; S.M. 0000-0002-5002-5041.

Cite this article as: Çelik E, Metintaş M, Ak G, Yıldırım H, Dündar E, Aydın N, et al. Ultrasound-guided pleural needle biopsy which needle for which patient: a prospective randomized study. Balkan Med J.; 2025; 42(4):321-8.

Thoracic ultrasound (US) is a bedside, cost-effective, radiation-free imaging modality that is easily and safely repeatable. Its use is increasingly widespread because of its effectiveness in detecting pleural effusion, assessing the etiology of pleural pathology, and guiding invasive diagnostic and therapeutic procedures, including needle biopsies.[2,5]

Two types of needles are used in US-guided pleural biopsies: the Abrams (US-ANPB) needle and the cutting needle (US-CNPB).[6,7] However, there remains a need for data to establish a consensus on the appropriate choice of needle in various clinical scenarios in terms of high diagnostic accuracy, reliability in identifying benign diagnoses, and safety profile regarding side effects. The importance of developing a patient-centered approach-rather than a one-size-fits-all strategy-in the diagnosis and management of pleural effusion is increasingly evident, given the heterogeneity of this disease group. This study aimed to compare and evaluate the diagnostic yield of the Abrams needle and cutting needle in US-guided pleural biopsy to determine the most appropriate needle choice for different clinical situations based on the pleural imaging characteristics.

MATERIALS AND METHODS

Trial design

This was a prospective, randomized, parallel-arm study. The study protocol adhered to the guidelines outlined by the Consolidated Standards of Reporting Trials.[8] The study was conducted between June 2022 and June 2023 at the Department of Chest Diseases, Eskişehir Osmangazi University Faculty of Medicine, and the Lung and Pleural Cancers Research and Clinical Center. The study was approved by the Ethical Committee of Eskişehir Osmangazi University (approval number: E-66175679-514.04.01-800014, date: 02.06.2022) and was conducted following the principles of the Declaration of Helsinki and registered at ClinicalTrials.gov (No: NCT06541470). Prior to randomization, all patients received detailed information regarding the study, and written informed consent was obtained from each participant.

Participants

The inclusion criteria were as follows: presence of undiagnosed exudative pleural effusion on clinical, radiological, laboratory, and cytological examination; willingness to participate in the study; and provision of written consent for randomization and participation in the study. The exclusion criteria included patients < 18 or > 85 years of age as well as those with any contraindication to pleural biopsy.

Sample size

The sample size was calculated using two distinct approaches. In the first approach, sample size was calculated based on the effect size, assuming an alpha error of 5%, a statistical power of 95%, and an effect size of 0.30. The two study groups (US-CNPB and US-ANPB) were compared for the primary outcome using a two-sided chi-squared test. The assumed effect size of 0.30 was chosen based on Cohen's conventional criteria for a medium effect, which is often considered appropriate in medical research, particularly in the absence of extensive prior data. This approach indicated that a minimum (min) of 87 patients were needed in each group. In the second approach, the sample size calculation was based on the anticipated diagnostic yields, estimated at 64% for CNPB and 82% for ANPB.[9] Using these assumptions and considering a power of 80% and an alpha error of 5%, the effect size was determined to be 0.30. Accordingly, the estimated sample size was 72 patients per group. All sample size calculations were performed using G*Power software version 3.1.9.4.

Randomization and blinding

Patients who met the inclusion criteria were randomized (1:1) into two groups: the US-ANPB group (n = 83) and the US-CNPB group (n = 82). Randomization was performed in blocks of six patients each. For each block, six cards-three labeled "A" and three labeled "B"-were prepared and placed into envelopes. A lot was drawn to ascertain which group (US-ANPB or US-CNPB) the A and B cards would represent. Card "A" represented the US-ANPB group, while card "B" represented the US-CNPB group. Each patient was allocated to a group by a blinded researcher who randomly drew one card from an envelope. Upon completion of each block, a new randomization block was initiated to continue patient allocation. Due to the nature of the study procedures, neither the patients nor the investigators were blinded to the treatment allocation. Only histopathologists responsible for interpreting the biopsy specimens were blinded to both the group allocation and clinical details of the patients.

Intervention

Needle biopsies were performed within the specialized pleural unit of the department. Patients were examined using thoracic US (Samsung SonoAce X7; Samsung Health Care Systems Co., Seoul, South Korea), and the findings were documented.

Based on the pleural imaging characteristics on ultrasonography, the optimal needle entry point was identified and marked on the patient's chest wall (Supplementary Figure 1). The selected site was checked using Doppler ultrasonography to ensure vascular safety, and an Abrams needle biopsy was performed at this point using a freehand technique. Because of the physical characteristics of Abrams needle, real-time application is not feasible.[10-14] Cutting needle biopsies were performed using a 14-gauge automated Tru-Cut needle. Tissue sampling was performed from the marked entry point using a real-time technique, with needle placement and movement continuously monitored under ultrasonographic guidance.[15-18] At least six samples were obtained from each type of needle biopsy. After tissue sampling, ultrasonography was used to assess for pneumothorax and bleeding, and thoracentesis was performed when indicated. In the absence of pleural thickening or lesion, the closest point to the diaphragm was identified using US, and sampling was performed by accessing a point between the mid-scapular and the posterior axillary lines.[19] The biopsy specimens were immediately fixed in formalin and submitted to the pathology department for histopathologic analysis. One specimen was stored for molecular analysis. In cases where tuberculous pleuritis was suspected, an additional biopsy specimen was submitted to the laboratory for bacteriologic examination for *M. tuberculosis*.

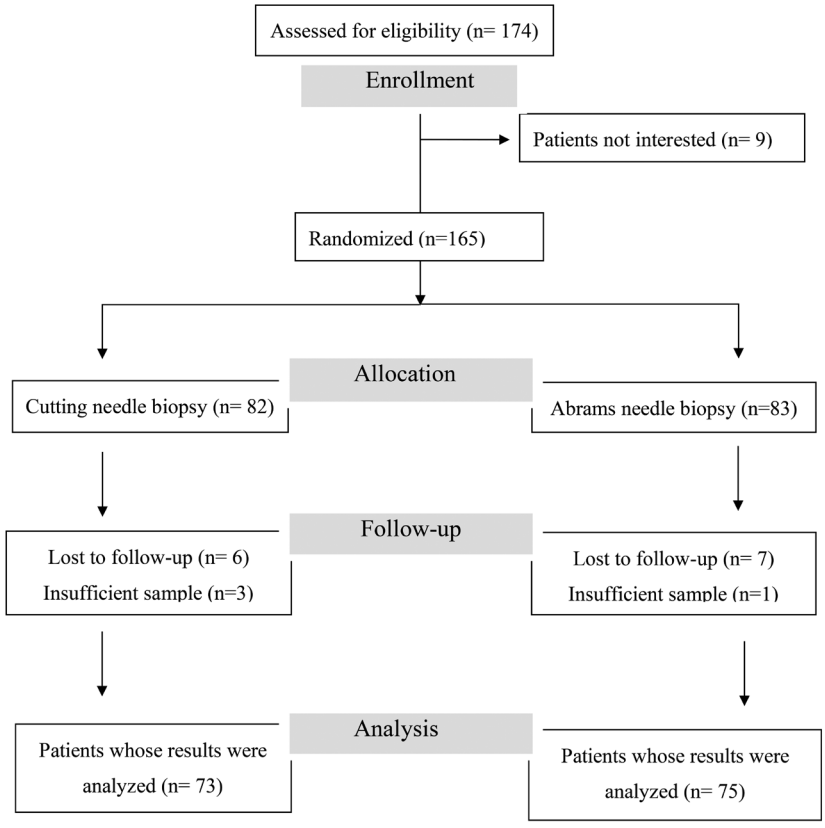

FIG. 1. Flow chart of the study.

Patients whose histopathological analysis following needle biopsy failed to yield a definitive diagnosis were referred for MT or video thoracoscopic surgery (VATS).[20] Patients who declined these diagnostic options, as well as those who underwent further invasive procedures but whose biopsy results were reported as non-specific pleuritic (NSP), were followed up for a min of 18 months to confirm the diagnosis of benign disease. Patients who developed recurrent effusion or pleuritic pain during follow-up were re-evaluated and underwent repeated invasive diagnostic tests when clinically indicated. NSP patients whose effusions resolved spontaneously, did not recur during follow-up, and for whom no specific benign disease diagnosis could be established were diagnosed with idiopathic pleural effusion.

Histopathological analysis

All biopsy specimens were evaluated by a single highly experienced pathologist specializing in respiratory pathology at the same faculty hospital. The cases were primarily divided into benign and malignant categories; the latter were further classified based on cell properties. Immunohistochemical staining was employed to differentiate tumors of mesothelial origin from those of epithelial origin. The panel included antibodies indicative of epithelial origin-such as carcinoembryonic antigen, Ber Ep4, B 72.3, CD 15 (Leu-M1), Claudin-4, TTF-1, Pax-8, napsin A, or p40/p63-as well as markers specific to mesothelial cells, including calretinin, Wilm's tumor 1, thrombomodulin, and cytokeratin 5/6. Additionally, when necessary, epithelial membrane antigen, p53, BAP1, and MTAP were used to distinguish reactive mesothelial hyperplasia from epithelioid mesothelioma. Broad-spectrum cytokeratin, D2-40, and GATA3 were used to differentiate sarcomatoid neoplasms from sarcomatoid or desmoplastic mesothelioma. Although broad-spectrum cytokeratin may also stain reactive mesothelial stroma, it is frequently employed in spindle cell lesions due to its ability to highlight growth patterns. When necessary, the specimens were also stained with Ziehl-Neelsen to detect acid-resistant bacilli (*M. tuberculosis*).

Outcomes

The primary outcome of this study was to determine the most appropriate biopsy needle-Abrams or cutting needle-based on pleural imaging characteristics observed on US. The safety profiles of the two biopsy needles for clinical use were also assessed as a secondary outcome.

Statistical analysis

A specific database was created, and SPSS (version 15.0, SPSS Inc., Chicago, Illinois) and MedCalc software (version 19.1.16, MedCalc Software Ltd., Ostend, Belgium) were employed for statistical analysis. Descriptive statistics were used to summarize patient characteristics, expressed as means and percentages. The t-test, χ^2

test, and two-tailed Fisher's exact test were used to compare groups. The primary endpoint of this study was to determine the sensitivity, specificity, negative likelihood ratio (-LR), and accuracy values with their confidence intervals and complication rates of both methods. Results are presented as effect sizes with 95% confidence intervals, and likelihood ratio tests were employed to ascertain statistical significance. An intention-to-treat (ITT) analysis was performed to determine the effect of participant dropouts on the outcomes within the randomized groups. The following analysis was performed upon completion of the study's primary outcome assessment. The post hoc power analysis revealed a statistical power of 82.1%.

RESULTS

The study group comprised 148 patients whose results could be evaluated and who completed follow-up. Of the 148 patients, 85 (57.4%) were male and 63 (42.6%) were female, with a mean age of 66.8 ± 12.2 years. Patient characteristics and final diagnoses are presented in Table 1.

Biopsy results for the study groups are presented in Table 2.

After the initial needle biopsies, a definitive histopathological diagnosis-malignant pleural disease or tuberculous pleuritis-was established in 68 of 148 patients (46%). Eighty (54%) patients were diagnosed with NSP. Of the 80 patients, 43 (53.8%) exhibited false-negative results. In the US-CNPB arm, there were 27 patients with false-negative results. Twelve patients were diagnosed with mesothelioma, 12 with metastatic pleural effusion, one with lymphohematogenous malignancy, one with sarcoma, and one with tuberculous pleurisy. In these patients, the final diagnosis was established by MT in 12 patients, VATS in four, open surgical biopsy in one, endobronchial ultrasonographic (EBUS) biopsy in three, repeated image-guided pleural needle biopsy in two, lung wedge biopsy in one, cytology (one by pleural fluid, one by pleural fluid/

TABLE 1. Study Groups.

Patients	Cutting needle n = 73	Abrams needle n = 75	*p*
Age, years, X ± SD	66.4 ± 12.5	67.2 ± 11.9	0.680
Male, n (%)	41 (56.2)	44 (58.7)	0.758
Female, n (%)	32 (43.8)	31 (41.3)	
Thoracic ultrasound imaging characteristics, n (%)			
Pleural thickening < 1 cm or only effusion, 124 (83.7)	58 (79.5)	66 (88.0)	0.126
Pleural thickening ≥ 1 cm, 24 (16.3)	15 (20.5)	9 (12.0)	
Final diagnosis, n (%)			
			0.673
Malignant, 105 (70.9)	55 (75.3)	50 (66.7)	
Pleural mesothelioma, 36 (34.3)	19 (34.5)	17 (34.0)	
Metastatic pleural diseases, 69 (65.7)	36 (65.5)	33 (66.0)	
Benign, 43 (29.1)	18 (24.7)	25 (33.3)	
Pleurisy tuberculosis, 6 (14.0)	3 (16.7)	3 (12.0)	
Other benign causes, 37 (86.0)	15 (83.3)	22 (88.0)	

SD, standard deviation. Other benign causes: benign asbestos pleurisy; para malignant pleural effusion; radiation- or drug-induced pleurisy; viral pleurisy; rheumatoid pleurisy; parapneumonic pleurisy as sequelae; cardiac injury; uremic pleural effusion.

TABLE 2. Outcomes in the Study Arms.

Outcome (n = 148)	Cutting needle (n = 73) n (%)	Abrams needle (n = 75) n (%)	*p*
False negative (n = 43, 29.0%)	27/73 (36.9)	16/75 (21.3)	**0.036**
Diffuse pleural mesothelioma (n= 21)	12/19 (63.2)	9/17 (52.9)	
Metastatic malignant pleural diseases (n = 20)	14/36 (38.9)	6/33 (18.2)	
Tuberculous pleurisy (n = 2)	1/3 (33.3)	1/3 (33.3)	
True positive (n = 68, 45.9%)	31/73 (42.5)	37/75 (49.3)	0.698
Diffuse pleural mesothelioma (n = 15)	7/19 (36.8)	8/17 (47.1)	
Metastatic malignant pleural diseases (n = 49)	22 /36 (61.1)	27/33 (81.8)	
Tuberculous pleurisy (n = 4)	2/3 (66.7)	2/3 (66.7)	
True negative (other benign diseases) (n = 37, 25.1%)	15/73 (20.5)	22/75 (29.3)	0.218

ascitic fluid) in two, and other methods (one by peripheral lymph node biopsy, one by bone marrow biopsy) in two. The number of patients with false-negative results in the US-ANPB arm was 16 (21.3%). Nine patients were diagnosed with mesothelioma, five with metastatic pleural effusion, one with lymphohematogenous malignant effusion, and one with tuberculous pleurisy. In these patients, the final diagnosis was confirmed employing four methods: four cases by MT, three by VATS, one by open surgical biopsy, two by EBUS, one by bronchial biopsy, one by lung wedge biopsy, one by cytology (pleural fluid), and three using other methods (one by ovarian biopsy, one by lymph node biopsy, and one by omentum biopsy).

The diagnostic values of US-CNPB and US-ANPB in the study groups are presented in Table 3.

The overall diagnostic accuracy, irrespective of the needle type, was 70.9%. The diagnostic accuracy of US-CNPB was significantly lower than that of US-ANPB (63.0% vs. 78.7%; $p = 0.036$). The ITT analysis revealed that the diagnostic accuracy of the Abrams needle was superior to that of the cutting needle ($p = 0.045$). The comparison of diagnostic accuracy between the cutting needle and the Abrams needle based on pleural thickness is illustrated in Figure 2.

The overall complication rates for US-CNPB and US-ANPB were 15.1% and 14.7%, respectively ($p = 0.945$). The distribution of needle complications based on pleural thickness is presented in Table 4.

Among the four patients who experienced major bleeding, two were diagnosed with metastatic malignant pleural disease, one with mesothelioma, and one with cardiac injury-related effusion. These patients only presented with pleural effusion without detectable pleural thickening on ultrasonography. Two patients who developed major bleeding required intervention with VATS. One patient required chest tube insertion and blood transfusion, while another was managed with a thin (8F) pleural catheter drainage. No pneumothorax patients required additional intervention, and no procedure-related deaths occurred.

DISCUSSION

This study is the first randomized study to compare the use of the Abrams needle and the cutting needle under thoracic US guidance. Both needles demonstrated comparable diagnostic yields in patients with pleural thickening ≥ 1 cm. However, cutting needles demonstrated more reliable results in patients with histopathologically confirmed NSP. However, for patients with pleural thickening ≤ 1 cm or isolated pleural effusion, the Abrams needle demonstrated a higher diagnostic yield.

Thoracic US is increasingly being utilized in clinical practice because of its advantages.[21,22] In a systematic review of 15 studies involving 1,553 patients, the overall diagnostic accuracy of real-time US-guided pleural needle biopsy was 85.6%, with a sensitivity of 77.6% for malignant pleural disease and 80.1% for tuberculous pleurisy.[23] In another systematic review of 24 studies involving 1,887 patients, the overall diagnostic rate for US-guided pleural needle biopsy using either real-time or freehand techniques was reported as 84%. In this review, the diagnostic rate for malignant pleural disease was 76%.[6]

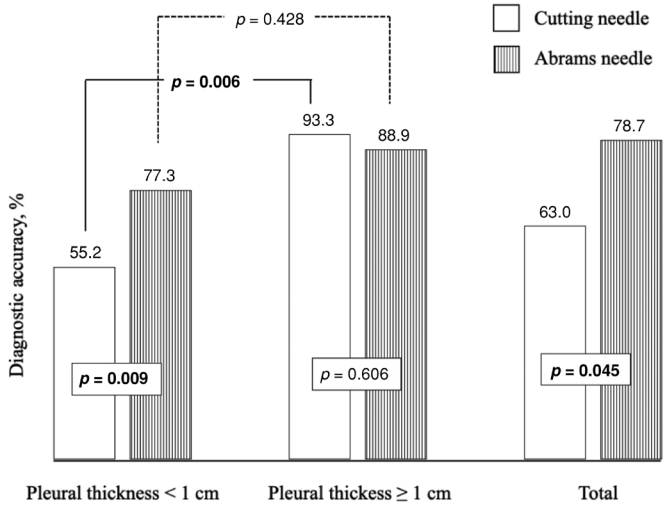

FIG. 2. The comparison of the diagnostic accuracy of the biopsy needles.

TABLE 3. Diagnostic Values of Biopsy Needles in the Study Arms.

Biopsy	Sensitivity, % 95% CI	Specificity, % 95% CI	Negative likelihood ratio	Accuracy, % 95% CI
All				
Cutting needle (n = 73)	53.5 (39.9-66.7)	100.0 (78.2-100.00)	0.47 (0.35-0.61)	63.0 (50.9-74.0)
Abrams needle (n = 75)	69.8 (55.7-81.7)	100.0 (84.6-100.0)	0.30 (0.20-0.45)	78.7 (67.7-87.3)
Pleural thickening < 1 cm				
Cutting needle (n = 58)	43.5 (28.9-58.9)	100.0 (73.5-100.0)	0.57 (0.44-0.73)	55.2 (41.5-68.3)
Abrams needle (n = 66)	68.1 (52.9-80.9)	100.0 (82.5-100.0)	0.32 (0.21-0.48)	77.3 (65.30-86.7)
Pleural thickening ≥ 1 cm				
Cutting needle (n = 15)	91.7 (61.52-99.79)	100.0 (29.24-100.00)	0.08 (0.01-0.54)	93.3 (68.1-99.8)
Abrams needle (n = 9)	83.3 (35.9-99.6)	100.0 (29.2-100.0)	0.17 (0.03-1.00)	88.9 (51.8-99.7)

*Positive likelihood ratio value could not be evaluated because it was infinite. CI, confidence interval.

TABLE 4. Distribution of Complications According to the Biopsy Needles.

	Pleural thickening < 1 cm or only effusion, n = 124		Pleural thickening ≥ 1 cm, n = 24	
Side effects	Cutting needle (n = 58), n (%)	Abrams needle (n = 66), n (%)	Cutting needle (n = 15), n (%)	Abrams needle (n = 9), n (%)
Pain	1 (1.7)	2 (3.0)	1 (6.6)	1 (11.1)
Hypotension	1 (1.7)	3 (4.5)	1 (6.6)	1 (11.1)
Pneumothorax	1 (1.7)	2 (3.0)	-	-
Minor bleeding	2 (3.4)	2 (3.0)	-	-
Major bleeding*	4 (6.9)	-	-	-

*Bleeding requiring intervention.

Which needle is more diagnostically sensitive in clinical practice?

In the current study, the overall diagnostic rate of US-ANPB was higher than that of US-CNPB, at 78.7% vs. 63.0%, respectively. Although the imaging modalities differ, randomized prospective studies have demonstrated that the diagnostic rate of the Abrams needle is higher than that of the cutting needle. In a study performed under US guidance, the diagnostic sensitivity of the cutting needle was 64%, while that of the Abrams needle was 82%; the difference was statistically significant.[9] In another study, the diagnostic rate of the Abrams needle under US guidance compared with the cutting needle was 81.8% vs. 65.2% in tuberculosis cases and 83.3% vs. 66.7% in malignant pleural pathologies; the differences were significant.[10] In a study conducted at our clinic, the diagnostic rate of US-CNPB with the freehand technique was 66.7%, while that of CT-guided Abrams needle biopsy was 82.4%; the difference was significant.[7] In observational studies, the diagnostic rate of cutting needles has been reported to vary between 54% and 94%.[17,24-26] Some authors have indicated that this variance is because of the difference between freehand and real-time techniques and that the real-time technique is more diagnostically sensitive.[2,5,19] Although this hypothesis seems reasonable, current studies have not provided sufficient evidence to conclusively support it. Some studies, however, report conflicting findings, suggesting no significant difference in diagnostic yield between the freehand and real-time techniques.[18] The diagnostic rates reported in studies using different techniques appear to be in a similar range.[9,10,17,24,27-31] In clinical practice, if pleural thickening or a lesion is detected on US-guided pleural imaging, biopsy with cutting needles can be employed as a real-time technique. The Abrams needle can only be used in the freehand technique under US guidance. Therefore, the technique used for the two needles in our study may not appear directly comparable at first glance, which could represent a potential limiting factor of the study results. However, if the aim is to compare the efficacy and safety of the cutting needle and the Abrams needle in US-guided biopsy, there is no viable alternative to their respective standard techniques of use.

Does pleural thickening affect the diagnostic rate and reliability of needle biopsy?

Although numerous studies have reported that pleural thickness or nodular pleural lesions are associated with the diagnostic yield of needle biopsy[7,12,17,27,31-34], there is also disagreement.[2] In our study, patients were divided into two groups based on US examination to discuss this important issue with prospective data: those with pleural thickening/lesion thickness ≤ 1 cm and those with pleural thickness ≥ 1 cm. The diagnostic rate in patients with pleural thickening ≥ 1 cm was high and significant in the cutting needle group compared with the other group (55.2% vs. 93.3%). No significant difference was detected in the diagnostic rate of the Abrams needle between the two groups (77.3% vs. 88.9%). However, as the primary aim of the study was to compare two types of needles, the subsequent subgroup analysis based on a pleural thickness cut-off of 1 cm, comprising only 24 patients, has limited statistical power. Therefore, these findings warrant confirmation in a larger cohort. Previous studies using quantitative measures on this topic have demonstrated that the diagnostic yield of needle biopsy under US is significantly lesser in patients with thinner pleura than in those with thicker pleura or pleural lesions such as nodularity.[7,15,17,27,29] According to a study by Wang et al., the diagnostic rate of US-CNPBwas significantly lower in patients with pleural thickness < 3 mm (67.6%) than in those with pleural thickness ≥ 3 mm (84.2%).[27] A separate study using a 3-mm pleural thickness reported similar results for the cutting needle.[17] In a study from our department using the freehand technique, the diagnostic rate of cutting needles was significantly lower in patients with pleural thickening < 1 cm (42.9%) compared to those with thickening ≥ 1 cm (80.0%).[7] In another study, the authors reported that US-CNPBdemonstrated a lower diagnostic yield for pleural thickening less than 1 cm.[15] In pleural abnormalities, thickening, or nodularity, the reported sensitivities of cutting needles are generally high, typically exceeding 80%.[29,35-37] In a series of US-CNPB targeting pleural lesions ≥ 4 cm, the diagnostic rate was reported to be as high as 93.4%.[38]

In their comprehensive review, Koegelenberg et al.[29] reported that, in their clinical practice, patients were stratified based on pleural lesion characteristics: In patients with uniform pleural thickening < 1-2 cm, they offered biopsy with an Abrams needle under US guidance. They employed a cutting needle for biopsy in patients with marked pleural thickening of > 1-2 cm. In patients without pleural thickening, they used an Abrams needle close to the diaphragm. In the study by Sharma et al.[39] comparing US-CNPB and MT, using a real-time technique similar to that used in the current study, they determined the diagnostic yield of US-CNPB to be 88% in patients with pleural thickening or nodularity greater than 1 cm, with no significant difference compared to MT. They concluded that

US-CPNB is a viable alternative to MT for diagnosing undiagnosed exudative pleural effusion in patients with pleural thickening or nodularity greater than 1 cm on radiological imaging.

Conversely, in the current study, in patients with pleural thickening of ≥ 1 cm, an -LR of 0.08 for US-CNPB for benign diagnosis indicated high reliability when the biopsy result was NSP. The -LR (0.17) for US-ANPB was lower than that for US-CNPB. The reliability of a benign diagnosis with a low -LR is recognized as an important consideration.[40] Therefore, physicians should be cautious when interpreting negative US-guided needle biopsy test results.[41] In patients with pleural thickening of ≤ 1 cm on US or isolated pleural effusion, the diagnostic accuracy of US-ANPB was higher than that of US-CNPB, but its -LR was 0.32. Unfortunately, this value indicates that a histopathological result of NSP does not reliably indicate benign pleural disease, despite the low -LR.

Side effects should be considered in the patient-centered approach to pleural biopsies

In a systematic review of 15 case series, including 1,553 patients who underwent image-guided biopsies, the overall incidence of adverse events was reported as 6.68%.[23] A meta-analysis including 1,342 patients who underwent US-guided biopsy and 361 participants for CT-guided biopsy reported the overall incidence of adverse events to be 3% for US-guided biopsy and 7% for CT-guided biopsy.[6] A series on image-guided pleural needle biopsies reported a pneumothorax rate of 11% and a bleeding rate of 7.5%.[42] In the current study, the overall complication rates based on the number of complications were 15.1% for the cutting needle and 14.7% for the Abrams needle. However, the study results indicated that patients without pleural thickening or with a thickness of less than 1 cm were at high risk of bleeding complications when biopsied with cutting needle. We believe that in cases where there is only pleural effusion or the pleura is too thin to be visualized on US, the tangential angulation of the cutting needle during the procedure may elevate the risk of the 1.5 cm cutting tip of the needle coming in contact with the intercostal vessels beneath the thin pleura. This position aggravates the risk of vascular trauma from the cutting needle. As the Abrams needle is inserted vertically, even in the thin pleura, the contact distance between the needle and intercostal vessels is greater compared to that of the cutting needle, potentially reducing the risk of vascular injury (Supplementary Figure 2). At this stage, Doppler evaluation of the vascular bed immediately before biopsy may offer limited prophylactic benefit due to the tangential trajectory of the needle across the thin pleura. In the presence of pleural thickening, the thickened pleura may act as a protective layer over the underlying vessel, reducing the possibility of the needle-cutting tip contacting the vessel. The distribution of adverse events and severity of needle biopsies observed in our study strongly underscore the importance of a "patient-centered approach" based on pleural imaging characteristics.

This study has certain limitations. The single-center design of the study is a limitation that may affect the generalizability of the results. However, for interventional procedure studies intended to inform and guide clinical practice, initially evaluating the study hypothesis in a single-center setting may be considered an appropriate and methodologically sound approach.

In conclusion, in patients with a pleural thickness of ≥ 1 cm on US examination, although both needles provide a sufficiently high diagnostic rate, US-CNPB should be preferred due to its superior diagnostic reliability in benign cases. Patients lacking high-risk factors for malignant pleural disease can be monitored at reasonable intervals without further invasive procedures. MT should be preferred in patients with pleural thickening of ≤ 1 cm or in those in whom isolated pleural effusion is detected on US. However, US-ANPB is appropriate for clinical use in clinics lacking MT facilities and exhibits a superior diagnostic rate and procedural safety compared to US-CNPB. Further intervention studies involving larger cohorts are needed to validate and substantiate these findings.

Acknowledgments: M. Metintaş and S. Metintaş had full access to all of the data in the study and took responsibility for the integrity of the data and the accuracy of the data analysis, including and especially any adverse effects. M. Metintaş, S. Metintaş, G. Ak, and E. Çelik had the idea for and designed the study. S.Metintaş performed all statistical analyses. The manuscript was drafted by M. Metintaş and was edited by M. Metintaş, S. Metintaş, and G. Ak. Abrams' pleural biopsy procedures and medical thoracoscopy were done by M. Metintaş, G. Ak, and H. Yıldırım. E. Dündar performed histopathological studies on the patient's biopsy samples. N.Aydın investigated CT scans of the patients. E. Çelik managed the patients in the clinic, who also contributed substantially to the data interpretation.

Ethics Committee Approval: The study was approved by the Ethical Committee of Eskişehir Osmangazi University (approval number: E-66175679-514.04.01-800014, date: 02.06.2022).

Informed Consent: All patients received detailed information regarding the study, and written informed consent was obtained from each participant.

Data Sharing Statement: The datasets analyzed during the current study are available from the corresponding author upon reasonable request.

Authorship Contributions: Concept- M.M., S.M.; Design- M.M., S.M.; Supervision- M.M., S.M.; Materials- E.D., N.A.; Data Collection or Processing- E.Ç., G.A., H.Y., E.D., N.A.; Analysis and/or Interpretation- M.M., S.M.; Literature Review- E.Ç., M.M.; Writing- E.Ç., M.M., G.A., H.Y., S.M.; Critical Review- M.M., G.A., H.Y., S.M.

Conflict of Interest: The authors declare that they have no conflict of interest.

Funding: Eskişehir Osmangazi University Research Fund partly supported this study.

Supplementary: https://www.balkanmedicaljournal.org/img/files/balkan-2025.2025-4-90-supplemantry.pdf

REFERENCES

1. Ak G, Metintas S, Taskın AN, et al. Evaluation of Exudative Pleural Effusions: A Multicenter, Prospective, Observational Study. *Lung*. 2022;200:807-815. [CrossRef]
2. Roberts ME, Rahman NM, Maskell NA, et al. British Thoracic Society Guideline for pleural disease. *Thorax*. 2023;78:1-42. [CrossRef]
3. Bibby AC, Maskell NA. Pleural biopsies in undiagnosed pleural effusions; Abrams vs image-guided vs thoracoscopic biopsies. *Curr Opin Pulm Med*. 2016;22:392-398. [CrossRef]
4. Hooper C, Lee YC, Maskell N. Investigation of a unilateral pleural effusion in adults: British Thoracic Society Pleural Disease Guideline 2010. *Thorax*. 2010;65:4-17. [CrossRef]
5. Patel KM, Ullah K, Patail H, Ahmad S. Ultrasound for Pleural Disease. Beyond a Pocket of Pleural Fluid. *Ann Am Thorac Soc*. 2021;18:749-756. [CrossRef]
6. Mei F, Bonifazi M, Rota M, et al. Diagnostic Yield and Safety of Image-Guided Pleural Biopsy: A Systematic Review and Meta-Analysis. *Respiration*. 2021;100:77-87. [CrossRef]

7. Metintas M, Yildirim H, Kaya T, et al. CT scan-guided Abrams' needle pleural biopsy versus ultrasound-assisted cutting needle pleural biopsy for diagnosis in patients with pleural effusion: a randomized, controlled trial. *Respiration*. 2016;91:156-163. [CrossRef]
8. Schulz KF, Altman DG, Moher D. CONSORT 2010 statement: updated guidelines for reporting parallel group randomised trials. *BMJ*. 2010;340:332. [CrossRef]
9. Abd-el Zaher AH, Salah I, Hantera M, Oreby R, Abaas E. Diagnostic utility of sonar guided biopsy in tuberculous effusion. *Egypt J Chest Dis Tuberc*. 2013;62:425-428. [CrossRef]
10. Koegelenberg CF, Bolliger CT, Theron J, et al. Direct comparison of the diagnostic yield of ultrasound-assisted Abrams and tru-cut needle biopsies for pleural tuberculosis. *Thorax*. 2010;65:857-862. [CrossRef]
11. Boy DP, Shaw JA, Koegelenberg CFN. Ultrasound-guided pleural biopsy. *Eurasian J Pulmonol*. 2023;25:1-11. [CrossRef]
12. Metintas M, Ak G, Yildirim H, et al. image-assisted pleural needle biopsy or medical thoracoscopy: which method for which patient? a randomized controlled triall. *Chest*. 2024;166:405-412. [CrossRef]
13. Sivakumar P, Jayaram D, Rao D, Dhileepan V, Ahmed I, Ahmed L. Ultrasound-guided Abrams pleural biopsy vs CT-guided tru-cut pleural biopsy in malignant pleural disease, a 3-year follow-up study. *Lung*. 2016;194:911-916. [CrossRef]
14. Botana-Rial M, Leiro-Fernández V, Represas-Represas C, González-Piñeiro A, Tilve-Gómez A, Fernández-Villar A. Thoracic ultrasound-assisted selection for pleural biopsy with Abrams needle. *Respir Care*. 2013;58:1949-1954. [CrossRef]
15. Iadevaia C, D'Agnano V, Pagliaro R, et al. Diagnostic Accuracy of Ultrasound Guided Percutaneous Pleural Needle Biopsy for Malignant Pleural Mesothelioma. *J Clin Med*. 2024;13:2600. [CrossRef]
16. Asciak R, Bedawi EO, Bhatnagar R, et al. British Thoracic Society Clinical Statement on pleural procedures. *Thorax*. 2023;78:43-68. [CrossRef]
17. Zhang Y, Tang J, Zhou X, Zhou D, Wang J, Tang Q. Ultrasound-guided pleural cutting needle biopsy: accuracy and factors influencing diagnostic yield. *J Thorac Dis*. 2018;10:3244-3252. [CrossRef]
18. Hassan M, Munavvar M, Corcoran JP. Pleural interventions: less is more? In: Maskell NA, Laursen CB, Lee YCG, et al., eds. Pleural Disease (ERS Monograph). *Sheffield, European Respiratory Society*. 2020; pp. 90–104.[CrossRef]
19. Shaw JA, Louw EH, Koegelenberg CFN. A practical approach to the diagnosis and management of malignant pleural effusions in resource-constrained settings. *Breathe (Sheff)*. 2023;19:230140. [CrossRef]
20. Janssen J, Maldonado F, Metintas M. What is the significance of non-specific pleuritis? A trick question. *Clin Respir J*. 2018;12:2407-2410. [CrossRef]
21. Fjaellegaard K, Petersen JK, Clementsen PF, Laursen CB, Bhatnagar R, Bodtger U. Additional Up-Front Thoracic Ultrasound in the Workup of Patients with Unilateral Pleural Effusion: A Prospective Observational Pilot Study. *Respiration*. 2023;102:377-385. [CrossRef]
22. Sundaralingam A, Bedawi EO, Rahman NM. Diagnostics in pleural disease. *Diagnostics (Basel)*. 2020;10:1046. [CrossRef]
23. Zhang Q, Deng MM, Li XL, Lu Y, Hou G. Thoracic ultrasound-guided real-time pleural biopsy in the diagnosis of pleural diseases: a systematic review and meta-analysis. *Expert Rev Respir Med*. 2023;17:805-813. [CrossRef]
24. Sitt JCM, Lee RKL, Chan AWH, Hui M, Wong KT, Yu SCH. Clinical Application, performance, and common pitfalls of ultrasound-guided pleural biopsy: our local experience. *Hong Kong J Radiol*. 2016;19:103-110. [CrossRef]
25. Botana Rial M, Briones Gómez A, Ferrando Gabarda JR, et al. Tru-cut needle pleural biopsy and cytology as the initial procedure in the evaluation of pleural effusion. *Arch Bronconeumol*. 2014;50:313-317. [CrossRef]
26. Hallifax RJ, Corcoran JP, Ahmed A, et al. Physician-based ultrasound-guided biopsy for diagnosing pleural disease. *Chest*. 2014;146:1001-1006. [CrossRef]
27. Wang J, Zhou X, Xie X, Tang Q, Shen P, Zeng Y. Combined ultrasound-guided cutting-needle biopsy and standard pleural biopsy for diagnosis of malignant pleural effusions. *BMC Pulm Med*. 2016;16:155. [CrossRef]
28. Chang DB, Yang PC, Luh KT, Kuo SH, Yu CJ. Ultrasound-guided pleural biopsy with Tru-Cut needle. *Chest*. 1991;100:1328-1333. [CrossRef]
29. Koegelenberg CF, Irusen EM, von Groote-Bidlingmaier F, Bruwer JW, Batubara EM, Diacon AH. The utility of ultrasound-guided thoracentesis and pleural biopsy in undiagnosed pleural exudates. *Thorax*. 2015;70:995-997. [CrossRef]
30. Diacon AH, Schuurmans MM, Theron J, Schubert PT, Wright CA, Bolliger CT. Safety and yield of ultrasound-assisted transthoracic biopsy performed by pulmonologists. *Respiration*. 2004;71:519-522. [CrossRef]
31. Diacon AH, Theron J, Schubert P, et al. Ultrasound-assisted transthoracic biopsy: fine-needle aspiration or cutting-needle biopsy? *Eur Respir J*. 2007;29:357-362. [CrossRef]
32. Park J, Park B, Lim JK, et al. Ultrasound-guided percutaneous needle biopsy for small pleural lesions: diagnostic yield and impact of CT and ultrasound characteristics. *AJR Am J Roentgenol*. 2021;217:699-706. [CrossRef]
33. Stigt JA, Groen HJ. Percutaneous ultrasonography as imaging modality and sampling guide for pulmonologists. *Respiration*. 2014;87:441-451. [CrossRef]
34. Sun W, Zhou Y, Yang C, et al. Contrast-enhanced ultrasound guided pleural biopsy improves diagnostic confidence for pleural based lesions: a 3-year prospective study. *BMC Pulm Med*. 2021;21: 34247611. [CrossRef]
35. Panou V, Bhatnagar R, Rahman N, et al. Advances in the diagnosis and follow-up of pleural lesions: a scoping review. *Expert Rev Respir Med*. 2024;18:423-434. [CrossRef]
36. Metintas M, Ak G, Metintas S, Yildirim H, Dündar E, Rahman N. Prospective study of the utility of computed tomography triage of pleural biopsy strategies in patients with pleural diseases. *J Bronchology Interv Pulmonol*. 2019;26:210-218. [CrossRef]
37. Sconfienza LM, Mauri G, Grossi F, et al. Pleural and peripheral lung lesions: comparison of US- and CT-guided biopsy. *Radiology*. 2013;266:930-935. [CrossRef]
38. Yamamoto N, Watanabe T, Yamada K, et al. Efficacy and safety of ultrasound (US) guided percutaneous needle biopsy for peripheral lung or pleural lesion: comparison with computed tomography (CT) guided needle biopsy. *J Thorac Dis*. 2019;11:936-943. [CrossRef]
39. Sharma S, Gupta N, Ish P, et al. Comparative study between ultrasound-guided closed pleural biopsy and thoracoscopic pleural biopsy in undiagnosed exudative pleural effusions. *Monaldi Arch Chest Dis*. 2025. [CrossRef]
40. Deeks JJ, Altman DG. Diagnostic tests 4: likelihood ratios. *BMJ*. 2004;329:168-169. [CrossRef]
41. Lin Z, Wu D, Wang J, Wang C, Huang M. Diagnostic value of ultrasound-guided needle biopsy in undiagnosed pleural effusions: A systematic review and meta-analysis. *Medicine (Baltimore)*. 2020;99:21076. [CrossRef]
42. Benamore RE, Scott K, Richards CJ, Entwisle JJ. Image-guided pleural biopsy: diagnostic yield and complications. *Clin Radiol*. 2006;61:700-705. [CrossRef]