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Original Article

Ultrasound- versus CT-guided Biopsy of Pleural-contact Pulmonary Lesions: A Comparative Analysis of Diagnostic Performance and Procedural Complications

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ABSTRACT

OBJECTIVE: To compare the diagnostic performance and complication profiles of ultrasound (US)-guided and computed tomography (CT)-guided biopsy in pleural-contact pulmonary lesions and to evaluate technical factors associated with pneumothorax development after CT-guided biopsy.

MATERIAL AND METHODS: This retrospective single-center study included 197 patients with pleural-contact pulmonary lesions who underwent image-guided transthoracic core needle biopsy between January 2023 and March 2026. Of these, 123 underwent CT-guided biopsies and 74 underwent US-guided biopsies. Diagnostic adequacy, diagnostic accuracy, and procedure-related complications were compared between the groups. Factors associated with pneumothorax after CT-guided biopsy were evaluated using univariate and multivariable logistic regression analyses.

RESULTS: Diagnostic adequacy was comparable between CT-guided and US-guided biopsies (93.5% vs. 89.2%, $P = 0.281$). Similarly, diagnostic accuracy did not differ significantly between the groups (93.0% vs. 97.0%, $P = 0.331$). Pneumothorax occurred in 34 patients (27.6%) following CT-guided biopsy, whereas none occurred after US-guided biopsy ($P < 0.001$). Chest tube placement was required in 7 patients (5.7%) in the CT-guided group and in none in the US-guided group ($P = 0.047$). In univariate analysis, the traversed aerated lung distance was associated with pneumothorax development (odds ratio, 1.056; 95% confidence interval, 1.005–1.110; $P = 0.031$); however, no independent predictor was identified in multivariable analysis.

CONCLUSION: US-guided biopsy of pleural-contact pulmonary lesions demonstrated diagnostic adequacy and diagnostic accuracy comparable to CT-guided biopsy and was associated with lower pneumothorax and chest tube placement rates in this retrospective cohort. When an adequate acoustic window and pleural contact are present, US guidance may be a safe and effective alternative biopsy approach for appropriately selected pleural-contact pulmonary lesions.

KEYWORDS: Biopsy, needle, diagnostic accuracy, lung neoplasms, pneumothorax, tomography, X-ray computed, ultrasonography

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INTRODUCTION

Transthoracic image-guided biopsy is a well-established and widely used procedure for the histopathological diagnosis of pulmonary lesions.[1] Computed tomography (CT)-guided biopsy has traditionally been considered the standard guidance modality because of its high spatial resolution and ability to visualize lesions regardless of location.[1,2] However, CT-guided procedures are associated with ionizing radiation exposure, prolonged procedure times, and procedure-related complications, particularly pneumothorax and pulmonary hemorrhage.[2,3] Pneumothorax remains the most common complication following transthoracic lung biopsy, and several lesion- and technique-related factors, including emphysema, lesion size, traversed aerated lung distance, and the number of pleural punctures, have been shown to influence its occurrence.[2,3]

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Ultrasound (US)-guided biopsy has emerged as a valuable alternative for selected peripheral pulmonary lesions, particularly those in contact with the pleura.[4,5] Compared with CT guidance, US guidance offers several practical advantages, including real-time needle visualization, the absence of radiation exposure, applicability at the bedside, lower cost, and shorter procedural duration.[4] Because US-guided biopsy may minimize or avoid traversal of aerated lung parenchyma, it has the potential to reduce the risk of pneumothorax.[3,4] Nevertheless, thoracic ultrasonography has important limitations, as lesion visualization and safe needle access may be restricted by scapular or rib interference, respiratory motion, or the absence of an adequate acoustic window.[6]

Several recent studies have demonstrated comparable diagnostic performance between US- and CT-guided biopsy techniques in selected peripheral or subpleural pulmonary lesions.[7,8] In a retrospective comparative study, Mychajlowycz et al.[8] reported similar diagnostic adequacy and complication rates between US- and CT-guided biopsy of subpleural lung and pleural lesions, while US-guided procedures were associated with shorter waiting and procedure times. However, previous studies have mainly focused on overall diagnostic success and complication rates, whereas technical parameters potentially contributing to complication development—such as pleural contact length, traversed distance through lung parenchyma, and number of pleural punctures—have not been sufficiently investigated. To our knowledge, few comparative studies have specifically evaluated the effects of pleural contact length and traversed aerated lung distance on pneumothorax development in pleural-contact pulmonary lesions.

Therefore, this study aimed to compare the diagnostic performance and complication profiles of US-guided versus CT-guided biopsies for pleural-contact pulmonary lesions. Factors associated with the development of pneumothorax were evaluated in patients undergoing CT-guided biopsy, with pneumothorax events enabling risk-factor analysis.

MATERIAL AND METHODS

Study Design and Patient Selection

This retrospective, single-center study included consecutive patients who underwent image-guided transthoracic biopsy for pulmonary lesions in contact with the pleura between January 2023 and March 2026. The study was approved by the Atatürk University Non-Interventional Clinical Research Ethics Committee prior to study initiation (decision no: 11; approval date: 02.06.2026), and the requirement for informed consent was waived because of the study's retrospective design.

Main Points

- Ultrasound (US)-guided biopsy of pleural-contact pulmonary lesions demonstrated diagnostic adequacy and accuracy comparable to computed tomography (CT)-guided biopsy.
- No pneumothorax occurred following US-guided biopsy, whereas 27.6% of CT-guided procedures resulted in pneumothorax.
- Chest tube placement was required only following CT-guided biopsy, underscoring the favorable safety profile of US guidance in appropriately selected lesions.
- When an adequate acoustic window and pleural contact are present, US guidance may be a safe and effective alternative approach to biopsy for appropriately selected lesions.

Patients who underwent US-guided or CT-guided transthoracic core needle biopsy for pulmonary lesions demonstrating pleural contact on preprocedural thoracic CT were included in the study. The patient selection process is summarized in Figure 1. A total of 289 patients underwent image-guided transthoracic lung biopsy during the study period. After exclusion of patients with non–pleural-contact pulmonary lesions (n = 74), incomplete clinical or imaging data (n = 8), unavailable pathology results (n = 4), and repeat biopsies of the same lesion (n = 6), 197 patients with pleural-contact pulmonary lesions were included in the final analysis. Of these, 123 underwent CT-guided biopsy and 74 underwent US-guided biopsy.

Pleural-contact lesions were defined as pulmonary lesions demonstrating a visible interface with the visceral pleura on preprocedural CT, without intervening aerated lung tissue between the lesion and pleural surface. Patients with incomplete clinical or imaging data, missing pathology results, or repeated biopsies of the same lesion were excluded.

Demographic characteristics, lesion features, procedural details, diagnostic adequacy, and procedure-related complications were retrospectively reviewed in the institutional electronic medical records and the picture archiving and communication system.

Imaging Evaluation

Preprocedural thoracic CT images were reviewed by an independent thoracic radiologist with 5 years' experience in thoracic imaging to assess lesion characteristics, including size, pleural contact length, location, cavitation, and presence of emphysema. Lesion size was defined as the maximum axial diameter on CT images. Pleural contact length was measured using electronic calipers and defined as the longest interface between the lesion and the pleural surface on axial CT images.

For CT-guided biopsies, the traversed distance through aerated lung parenchyma was additionally measured as the length of aerated lung tissue crossed by the biopsy needle from the pleural entry point to the lesion margin. In all US-guided procedures, the biopsy trajectory was planned through the pleural-contact portion of the lesion without traversing aerated lung parenchyma.

Biopsy Procedures

The choice of imaging guidance modality was determined according to lesion visibility, accessibility, safe needle trajectory, and the presence of an adequate acoustic window.

To minimize operator-related variability, all US-guided and CT-guided biopsy procedures were performed by the same interventional thoracic radiologist with 8 years of experience in thoracic imaging and image-guided transthoracic interventions. The number of pleural punctures and core tissue samples obtained during each procedure was recorded.

Ultrasound-guided Biopsy

US-guided biopsies were performed in real time using a US system (Aplio 500; Toshiba Medical Systems Corporation, Otawara, Japan) equipped with a 3–6 MHz convex transducer. Following sterile preparation and local anesthesia, transthoracic core needle biopsy was performed using a 16-gauge biopsy needle under continuous real-time ultrasonographic guidance (Figure 2). Depending on lesion characteristics and specimen adequacy, one or two core tissue samples were obtained from each lesion.

Immediately after the procedure, a posteroanterior chest radiograph was obtained to assess procedure-related complications. Follow-up posteroanterior chest radiographs were routinely obtained four hours after the procedure.

Computed Tomography-guided Biopsy

CT-guided biopsies were performed using a conventional 320-row detector CT scanner (Aquilion ONE Vision; Toshiba Medical Systems Corporation, Otawara, Japan). Initial planning CT images were obtained to determine the safest needle trajectory while minimizing traversal of aerated lung parenchyma whenever possible. Following sterile preparation and local anesthesia, biopsies were performed using the coaxial technique with an 18-gauge core biopsy needle advanced to the target lesion through a coaxial introducer needle (Figure 3). Because a coaxial technique was routinely used, a single pleural puncture was performed in all patients regardless of the number of tissue cores obtained. Three core tissue samples were routinely obtained from each lesion.

Figure 1. Flowchart of patient selection

CT: computed tomography, US: ultrasound

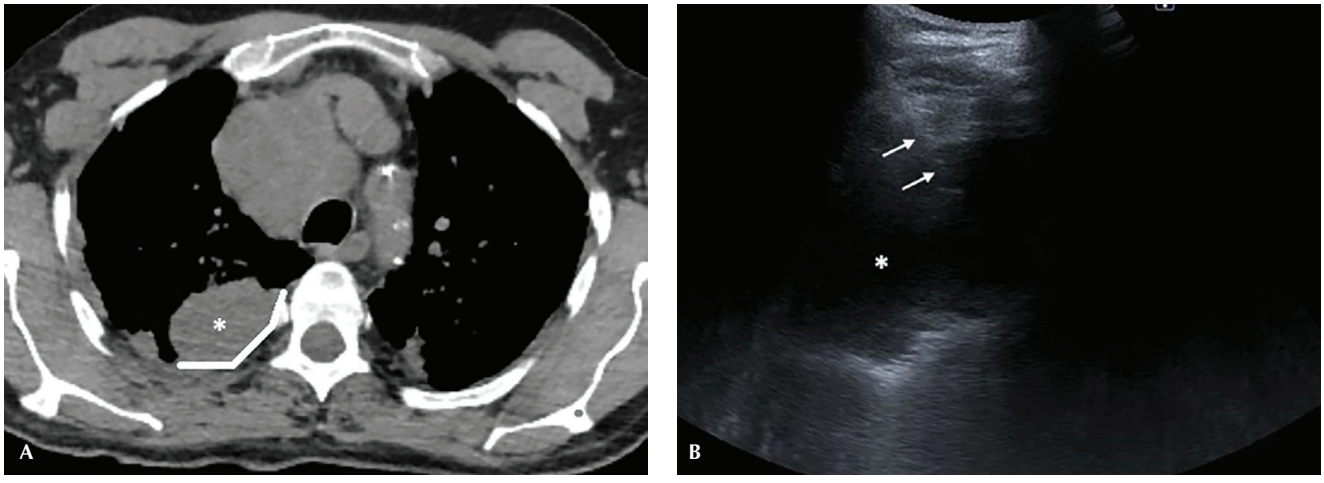

Figure 2. Pleural-contact pulmonary adenocarcinoma in a 65-year-old man. (A) Axial CT image demonstrates a right lower lobe pleural-contact lesion (asterisk); the white line indicates the pleural contact length. (B) Corresponding ultrasound image demonstrates the lesion (asterisk). Arrows indicate the biopsy needle trajectory during ultrasound-guided biopsy

CT: computed tomography

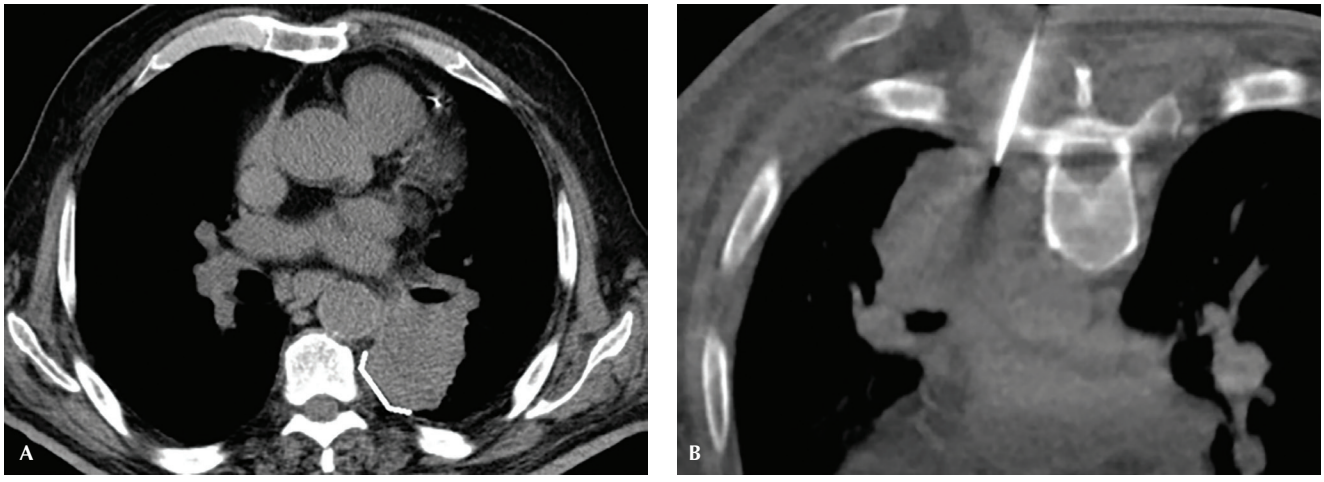

Figure 3. Pleural-contact squamous cell carcinoma in a 68-year-old man. (A) Axial CT image demonstrates the lesion; the white line indicates the pleural contact length. (B) CT-guided core needle biopsy of the lesion

CT: computed tomography

Immediately after the procedure, control CT images were acquired to assess procedure-related complications. In addition, follow-up posteroanterior chest radiography was routinely performed four hours after the procedure.

Outcome Measures

The primary outcomes of the study were diagnostic adequacy and procedure-related complications.

As part of routine clinical practice, histopathological evaluation was performed by experienced pathologists blinded to the imaging guidance modality used for biopsy. Final pathology reports were retrospectively reviewed for this study. Diagnostic adequacy was defined as the acquisition of sufficient tissue for histopathological evaluation. Specimens yielding a malignant diagnosis, benign inflammatory or infectious lesions, granulomatous inflammation, fibrotic/reactive lung tissue, mesenchymal proliferations, or benign lung parenchyma were considered diagnostically adequate. Specimens containing only necrotic material, nonrepresentative tissue (e.g., skeletal muscle, adipose tissue, or fibroadipose tissue), or insufficient material for pathological interpretation were considered non-diagnostic.

Diagnostic accuracy was assessed in diagnostically adequate biopsy specimens. A biopsy result was considered accurate when the histopathological diagnosis was concordant with the final diagnosis established by surgical pathology, repeat biopsy, or clinical-radiological follow-up. Overall diagnostic accuracy was calculated by including all biopsy procedures, with non-diagnostic biopsy results considered clinical failures, thereby reflecting diagnostic performance in the entire study population.

Procedure-related complications, including pneumothorax, the requirement for chest tube placement, and hemoptysis, were recorded. Pneumothorax was defined as the presence of pleural air detected on immediate postprocedural CT or follow-up chest radiography. Complications were classified according to the Society of Interventional Radiology classification system.

Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics for Windows, version 24.0 (IBM Corp., Armonk, NY, USA). The distribution of continuous variables was assessed using the Shapiro–Wilk test, Q–Q plots, skewness, and kurtosis. Normally distributed variables are presented as mean ± standard deviation, whereas non-normally distributed variables are presented as median and interquartile range. Comparisons between two independent groups were performed using the independent-samples t test for normally distributed variables and the Mann–Whitney U test for non-normally distributed variables. Categorical variables were compared using the chi-square test or Fisher's exact test, as appropriate.

Factors associated with pneumothorax were evaluated only among patients who underwent CT-guided biopsy, because no pneumothorax events occurred in the US-guided biopsy group. Univariate logistic regression analysis was initially performed to assess potential risk factors. Variables with a P value <0.10 in the univariate analysis were subsequently included in the multivariable logistic regression model. Model calibration was assessed using the Hosmer–Lemeshow goodness-of-fit test. Odds ratios (ORs) for lesion diameter, pleural contact length, and traversed lung distance were calculated per 1-mm increase in each variable. Statistical significance was defined as a two-sided P value <0.05.

RESULTS

A total of 197 patients with pleural-contact pulmonary lesions were included in the study. Of these, 123 underwent CT-guided biopsy and 74 underwent US-guided biopsy. Baseline patient and lesion characteristics are summarized in Table 1. There were no significant differences between the groups regarding age, sex distribution, emphysema prevalence, or lesion location (all $P > 0.05$). However, lesions in the US-guided group were significantly larger than those in the CT-guided group (median diameter: 77 mm vs. 53 mm; $P < 0.001$) and had a greater pleural contact length (median: 51 mm vs. 32 mm; $P < 0.001$). Cavitary lesions were more frequently encountered in the CT-guided group than in the US-guided group (22.8% vs. 5.4%, $P = 0.001$) (Table 1).

Table 1. Baseline patient and lesion characteristics

Variable	CT-guided (n = 123)	US-guided (n = 74)	*P* value
Age (years)	64.2±11.7	63.6±16.8	0.598
Male sex, n (%)	95 (77.2)	60 (81.1)	0.592
Emphysema, n (%)	60 (48.8)	32 (43.2)	0.451
Lesion diameter (mm)	53 (40–72)	77 (46–99)	<0.001
Pleural contact length (mm)	32 (17–54)	51 (33–95)	<0.001
Cavitation, n (%)	28 (22.8)	4 (5.4)	0.001
Lesion location, n (%)			0.09
• Upper lobe	78 (63.4)	39 (52.7)	
• Middle lobe	2 (1.6)	1 (1.4)	
• Lower lobe	43 (35.0)	34 (45.9)	

Data are presented as mean ± standard deviation, median (interquartile range), or number (%), as appropriate
CT: computed tomography, US: ultrasound

Procedural characteristics, diagnostic performance, and complication rates are presented in Table 2. The median number of pleural punctures was significantly lower in the CT-guided group because a coaxial technique with a single pleural puncture was routinely used, whereas repeated punctures were occasionally required during US-guided procedures ($P < 0.001$). Traversed aerated lung distance was significantly greater in the CT-guided group (3.5 ± 7.8 mm vs. 0 mm, $P < 0.001$).

Diagnostic adequacy was comparable between CT-guided and US-guided biopsy procedures (93.5% vs. 89.2%, $P = 0.281$). Similarly, diagnostic accuracy did not differ significantly between the two groups (93.0% vs. 97.0%, $P = 0.331$). When non-diagnostic biopsy results were considered clinical failures, overall diagnostic accuracy remained comparable between the CT-guided and US-guided groups (87.0% vs. 86.5%, respectively; $P = 0.925$). Regarding procedure-related complications, pneumothorax developed in 34 patients (27.6%) following CT-guided biopsy, whereas no pneumothorax developed following US-guided biopsy ($P < 0.001$). Chest tube placement was required in seven patients (5.7%) in the CT-guided group and in no patients in the US-guided group ($P = 0.047$). The incidence of hemoptysis was low in both groups and did not differ significantly between CT-guided and US-guided biopsies (1.6% vs. 2.7%, $P = 0.629$) (Table 2).

Because no pneumothorax events occurred in the US-guided group, analysis of pneumothorax-related risk factors was performed only among patients who underwent CT-guided biopsy. In univariate logistic regression analysis, traversed aerated lung distance was significantly associated with pneumothorax development [OR, 1.056; 95% confidence interval (CI), 1.005–1.110; $P = 0.031$]. Pleural contact length demonstrated a borderline association with pneumothorax occurrence (OR, 0.986; 95% CI, 0.971–1.002; $P = 0.092$). Age, sex, emphysema, lesion diameter, and cavitation were not significantly associated with pneumothorax development (Table 3). In a subgroup analysis of CT-guided biopsies, pneumothorax rates did not differ significantly between cavitary and non-cavitary lesions [17.9% (5/28) vs. 30.5% (29/95), respectively; $P = 0.234$].

Table 2. Procedural characteristics, diagnostic performance, and complications

Variable	CT-guided (n = 123)	US-guided (n = 74)	*P* value
Procedural characteristics			
Pleural puncture number	1 (1–1)	1 (1–3)	<0.001
Traversed lung distance (mm)	3.5±7.8	0	<0.001
Diagnostic performance			
Diagnostic adequacy, n (%)	115 (93.5)	66 (89.2)	0.281
Diagnostic accuracy among adequate biopsies, n (%)	107/115 (93.0)	64/66 (97.0)	0.331
Overall diagnostic accuracy, n (%)	107/123 (87.0)	64/74 (86.5)	0.925
Complications			
Pneumothorax, n (%)	34 (27.6)	0	<0.001
Chest tube placement, n (%)	7 (5.7)	0	0.047
Hemoptysis, n (%)	2 (1.6)	2 (2.7)	0.629

Diagnostic accuracy among adequate biopsies was calculated after exclusion of non-diagnostic specimens. Overall diagnostic accuracy was calculated by considering non-diagnostic biopsy results as clinical failures
CT: computed tomography, US: ultrasound

Variables with a *P* value <0.10 in univariate analysis were subsequently entered into the multivariable logistic regression model. In multivariable analysis, neither pleural contact length (adjusted OR, 0.989; 95% CI, 0.973–1.005; *P* = 0.175) nor traversed aerated lung distance (adjusted OR, 1.048; 95% CI, 0.998–1.101; *P* = 0.061) remained independently associated with pneumothorax development (Table 4). The Hosmer–Lemeshow goodness-of-fit test indicated adequate fit of the multivariable logistic regression model (*P* = 0.745).

DISCUSSION

In the present study, we compared the diagnostic performance and complication profiles of US-guided and CT-guided biopsies in patients with pleural-contact pulmonary lesions. The principal findings were threefold. First, US-guided biopsy demonstrated diagnostic adequacy and accuracy comparable to those of CT-guided biopsy. Second, procedure-related complications—particularly pneumothorax and the need for chest tube placement— were significantly lower in the US-guided group. Third, although traversed aerated lung distance was associated with the development of pneumothorax in univariate analysis, multivariable analysis did not identify any independent predictors of pneumothorax.

CT-guided transthoracic biopsy remains the reference standard for tissue sampling of pulmonary lesions because of its high diagnostic performance and broad applicability, regardless of lesion location.[2] However, pneumothorax and pulmonary hemorrhage continue to represent the most frequent procedure-related complications, with reported pneumothorax rates ranging from approximately 15% to 35% in contemporary series.[2,9] Consequently, alternative image-guidance techniques that can maintain diagnostic performance while reducing complications remain of considerable clinical interest.

Our findings demonstrated no significant difference in diagnostic adequacy between CT-guided and US-guided biopsies (93.5% vs. 89.2%). Similarly, diagnostic accuracy among adequate specimens was comparable between CT-guided and US-guided biopsy procedures (93.0% vs. 97.0%). These findings are consistent with previous studies that report equivalent diagnostic performance of US-guided biopsy for carefully selected peripheral pulmonary lesions.[7-9] In a comparative study, Yamamoto et al.[7] reported similar diagnostic yields and safety profiles between US-guided and CT-guided biopsy for peripheral lung and pleural lesions. Likewise, Mychajlowycz et al.[8] demonstrated comparable diagnostic adequacy between the two techniques while reporting shorter procedure times and waiting times for US-guided procedures. More recently, Zhou et al.[10] reported comparable diagnostic outcomes between US-guided and CT-guided biopsy in subpleural pulmonary lesions, further supporting the feasibility of US guidance in appropriately selected patients. In addition, a recent meta-analysis by Li et al.[11] confirmed the high diagnostic performance of US-guided core needle biopsy for peripheral pulmonary lesions. Collectively, these findings support the concept that US guidance can provide diagnostic performance equivalent to CT guidance when an adequate acoustic window and pleural contact are present. However, differences in biopsy technique between the two groups should also be considered when interpreting diagnostic outcomes. CT-guided procedures used an 18-gauge coaxial technique with three routinely obtained core samples, whereas US-guided procedures used a 16-gauge needle with one or two core samples. Therefore, differences in needle size, coaxial technique, and the number of tissue samples may have influenced diagnostic performance and should be considered when comparing the two guidance methods. Furthermore, the numerically higher diagnostic accuracy observed in the US-guided group, despite fewer core samples obtained, should not be interpreted as indicating superiority of US guidance alone. This finding may reflect multiple factors, including the selection of technically favorable lesions with larger sizes and broader pleural contact, as well as procedural advantages of US guidance, such as real-time needle visualization and the ability to target viable solid components while avoiding necrotic areas. In addition, the use of a larger 16-gauge biopsy needle in the

Table 3. Univariate logistic regression analysis of factors associated with pneumothorax after CT-guided biopsy

Variable	Odds ratio	95% CI	*P* value
Age	1.015	0.980–1.052	0.408
Male sex	2.026	0.830–4.942	0.121
Emphysema	1.070	0.485–2.358	0.867
Lesion diameter	0.993	0.977–1.009	0.366
Pleural contact length	0.986	0.971–1.002	**0.092**
Traversed lung distance	1.056	1.005–1.110	**0.031**
Cavitation	2.021	0.699–5.841	0.194

ORs for continuous variables are reported per 1-mm increase
OR: odds ratio, CI: confidence interval, CT: computed tomography

Table 4. Multivariable logistic regression analysis of pneumothorax following CT-guided biopsy

Variable	Adjusted odds ratio	95% CI	*P* value
Pleural contact length	0.989	0.973–1.005	0.175
Traversed lung distance	1.048	0.998–1.101	0.061

Variables with *P* < 0.10 in univariate analysis were included in the multivariable model. ORs for continuous variables are reported per 1-mm increase
OR: odds ratio, CI: confidence interval, CT: computed tomography

US-guided group may have contributed to obtaining adequate tissue samples despite yielding fewer core specimens.

An important observation of the present study was the markedly different complication profiles between the two groups. No pneumothorax occurred following US-guided biopsy, whereas pneumothorax developed in 27.6% of CT-guided procedures; chest tube placement was required in 5.7% of patients. Although the absolute complication rates reported in the literature vary depending on patient selection and procedural technique, our findings are consistent with previous reports demonstrating substantially lower pneumothorax rates with US-guided biopsy of pleural-based lesions.[8,12] The most likely explanation is that aerated lung was not traversed during US-guided procedures.[9] Despite a higher median number of pleural punctures in the US-guided group, no pneumothorax occurred after US-guided biopsy. This finding suggests that avoidance of traversing aerated lung tissue may be a more important determinant of pneumothorax risk than the number of pleural punctures. In our study, all US-guided biopsies were performed through the pleural-contact portion of the lesion, resulting in a traversed aerated lung distance of zero. In contrast, even minimal passage through aerated lung tissue during CT-guided biopsy may create a pleural-alveolar communication and increase the risk of pneumothorax.[9]

The study specifically focused on pleural-contact pulmonary lesions, a subgroup that has received limited attention in the literature.[12] Most previous comparative studies have evaluated heterogeneous cohorts containing both pleural-contact and non–pleural-contact lesions.[8,12] By restricting the analysis to lesions with direct pleural contact, we attempted to minimize selection heterogeneity and to better evaluate the clinical utility of US guidance for lesions theoretically amenable to both techniques. Our results suggest that when a lesion is visible sonographically and demonstrates adequate pleural contact, US guidance may be considered an effective first-line approach because it achieves similar diagnostic performance while avoiding radiation exposure and reducing procedure-related complications.

Another notable aspect of this study was the evaluation of technical factors potentially associated with pneumothorax development. Previous studies and consensus guidelines have identified lesion size, emphysema, traversed lung distance, and the number of pleural punctures as important determinants of pneumothorax risk.[9,13,14] In our cohort, the traversed aerated lung distance was significantly associated with pneumothorax on univariate analysis. However, this association did not remain statistically significant in the multivariable model. Although the traversed aerated lung distance remained close to the threshold for statistical significance (P = 0.061), the small number of pneumothorax events may have reduced the statistical power to identify independent predictors. Therefore, the absence of a statistically significant association should be interpreted with caution. Nevertheless, the findings suggest that the development of pneumothorax is likely to be multifactorial and cannot be attributed to a single technical parameter. Similarly, pleural contact length demonstrated a borderline association in univariate analysis but did not retain independent significance after adjustment. This finding differs somewhat from the results reported by Imamine et al.[14], who identified pleural contact length as a significant determinant of the occurrence of pneumothorax during US-guided lung biopsy.

Lesions in the US-guided group were significantly larger and had greater pleural contact lengths than those in the CT-guided group. This finding reflects routine clinical practice, in which the selection of the imaging guidance modality was influenced by lesion characteristics and procedural feasibility. Larger lesions with broader pleural interfaces provide better sonographic visualization and a safer acoustic window; therefore, these lesions were more likely to be selected by the proceduralist for US-guided biopsy. Consequently, some degree of selection bias and confounding by indication is unavoidable in retrospective comparisons between the two techniques. In addition, cavitary lesions were significantly more frequent in the CT-guided group than in the US-guided group. This imbalance likely reflects real-world biopsy selection patterns, since cavitary lesions may provide a less favorable sonographic window and therefore be preferentially referred for CT-guided biopsy. However, an additional subgroup analysis of CT-guided procedures demonstrated that pneumothorax rates did not differ significantly between cavitary and non-cavitary lesions (17.9% vs. 30.5%, respectively). Although the unequal distribution of cavitary lesions represents a potential selection factor, cavitation itself did not appear to be a major determinant of pneumothorax development in our cohort. Despite these baseline differences, diagnostic adequacy and accuracy remained comparable between the two groups. However, these baseline differences should be carefully considered when interpreting the observed differences in complication rates. Larger lesions with broader pleural interfaces provide improved sonographic visibility, facilitate safer needle trajectory planning, and may inherently reduce the risk of pneumothorax. Therefore, the lower pneumothorax rate observed in the US-guided group cannot be attributed solely to the imaging guidance modality, but likely reflects the combined effects of US guidance and favorable lesion characteristics. Accordingly, these findings should be interpreted within the context of appropriately selected pulmonary lesions in contact with the pleura, rather than as evidence that US guidance is universally superior to CT guidance.

The present study has several strengths. All procedures were performed at a single tertiary center using standardized biopsy protocols and were reviewed according to predefined imaging and pathological criteria. Furthermore, we evaluated diagnostic adequacy and diagnostic accuracy separately, and analyzed technical variables such as pleural contact length and traversed aerated lung distance. These factors allowed a more detailed assessment of both diagnostic performance and procedural safety.

Study Limitations

This study has several limitations. First, differences in post-procedural imaging assessments between the two biopsy techniques may have introduced detection bias. CT-guided procedures were evaluated with immediate postprocedural CT imaging, whereas US-guided procedures were assessed using postprocedural chest radiography. Therefore, small

or clinically insignificant pneumothoraces may have been detected more frequently after CT-guided biopsy, and the observed difference in pneumothorax rates may partly reflect differences in detection sensitivity rather than a true difference in complication rates. However, clinically relevant outcomes, such as the need for chest tube placement, are less likely to be influenced by differences in imaging sensitivity. Second, the retrospective single-center design and non-randomized selection of the imaging guidance modality introduce potential selection bias. The choice of imaging guidance modality was influenced by lesion visibility and accessibility. Consequently, the US-guided group included significantly larger lesions with longer pleural contact lengths, which may have facilitated lesion visualization and reduced procedural risk. Although the distribution of lesion locations did not differ statistically between groups, the slightly higher proportion of lower-lobe lesions in the US-guided group may represent a residual confounding factor due to greater respiratory motion. Therefore, the observed differences in complication rates may partly reflect baseline lesion characteristics rather than the imaging guidance modality. Although propensity-score matching could have further reduced the effects of baseline differences between groups, it was not performed because of the relatively limited sample size, particularly in the US-guided cohort, and the potential risk that matching would substantially reduce the analyzable study population. Therefore, the results should be interpreted as reflecting outcomes observed in appropriately selected pleural-contact lesions rather than as a direct comparison between two completely equivalent patient groups. Biopsy techniques were not identical between the two groups, including differences in needle size, in the use of a coaxial system, and in the number of core samples obtained, which may represent a potential source of procedural bias. Third, the relatively limited number of pneumothorax events may have reduced the statistical power of the multivariable analysis. Furthermore, all biopsy procedures were performed by a single experienced thoracic radiologist. Although this approach reduced operator-related variability and provided procedural consistency, it may limit the generalizability of the findings. Therefore, similar diagnostic and safety outcomes may not be directly reproducible in centers with different levels of operator experience or procedural expertise. Finally, procedure duration, radiation exposure parameters, and patient-related procedural outcomes such as pain, comfort, and satisfaction were not systematically recorded due to the retrospective design of the study and, therefore, could not be compared between the two techniques. Although the absence of radiation exposure represents an inherent advantage of US guidance, further prospective studies incorporating procedural time, radiation dose, and patient-centered outcomes are needed to provide a more comprehensive comparison of these guidance modalities.

CONCLUSION

In this retrospective comparison of pleural-contact pulmonary lesions, US-guided biopsy demonstrated diagnostic adequacy and accuracy comparable to those of CT-guided biopsy, and was associated with lower rates of pneumothorax and chest tube placement. Given the non-randomized design and differences in baseline lesion characteristics, these findings suggest that US guidance may represent an effective and safe alternative biopsy approach for appropriately selected pleural-contact pulmonary lesions with an adequate acoustic window.

Ethics

Ethics Committee Approval: The study was approved by the Atatürk University Non-Interventional Clinical Research Ethics Committee prior to study initiation (decision no: 11; approval date: 02.06.2026).

Informed Consent: The requirement for informed consent was waived because of the study's retrospective design.

Footnotes

Authorship Contributions

Surgical and Medical Practices: M.Y., E.P., A.K., Concept: M.Y., A.K., Design: M.Y., A.T.A., Data Collection or Processing: M.Y., E.P., Analysis or Interpretation: A.T.A., A.K., Literature Search: M.Y., E.P., A.K., Writing: M.Y., A.T.A.

Conflict of Interest: No conflict of interest was declared by the authors.

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