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Original Article

Factors influencing the diagnostic accuracy of lung cancer using endobronchial ultrasound-guided transbronchial needle aspiration

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Abstract: Objectives: Endobronchial ultrasound-guided transbronchial needle aspiration (EBUS-TBNA) is a key diagnostic modality for lung cancer, yet its accuracy varies based on several factors. This study aims to identify factors influencing the diagnostic accuracy of EBUS-TBNA for lung cancer detection. Methods: A retrospective case-control study was conducted on lung cancer patients diagnosed at Gaozhou People's Hospital from October 2021 to September 2023. Patients with lung cancer confirmed by EBUS-TBNA, bronchoscopy with direct biopsy, or surgical intervention were re-evaluated using EBUS-TBNA. Based on diagnostic accuracy, they were classified into an accurate group (n = 204) and an inaccurate group (n = 41). An external validation cohort included 58 lung cancer patients. Data collection encompassed patient demographics and EBUS-TBNA findings. Logistic regression and receiver operating characteristic (ROC) curve analyses were performed to determine factors influencing detection accuracy. A generalized linear model incorporating independent influencing factors was developed to estimate the likelihood of inaccurate EBUS-TBNA detection of lung cancer. Results: Smoking history [dds ratio (OR), 7.948; $P < 0.001$] and a diagnosis of small cell lung cancer (OR, 3.996; $P = 0.007$) were significantly associated with an increased risk of inaccurate detection. In contrast, a lesion diameter of ≥ 3 cm (OR, 0.343; $P = 0.026$) and linear filamentous changes in aspirate samples (OR, 0.106; $P < 0.001$) were strongly correlated with accurate detection. Larger lesion size and specific sample characteristics were also significant predictors in the external validation cohort ($P < 0.05$). Multivariate logistic regression confirmed these factors as independent predictors of diagnostic accuracy. The predictive model demonstrated robust performance [area under the curve (AUC) = 0.882], with external validation yielding a comparable AUC of 0.877. Conclusion: Smoking history, pathologic subtype, lesion size and aspirate sample characteristics significantly affected the diagnostic accuracy of EBUS-TBNA in lung cancer detection. These insights underscore the importance of considering these factors in clinical practice to optimize EBUS-TBNA's diagnostic performance.

Keywords: Lung cancer, endobronchial ultrasound-guided transbronchial needle aspiration, diagnostic accuracy, lesion size, smoking history, predictive model

Introduction

Lung cancer remains one of the most prevalent and deadliest malignancies worldwide, posing a substantial public health challenge due to its high morbidity and mortality rates. It accounts for approximately 11% of all cancer diagnoses yet contributes to 18% of cancer-related deaths globally, underscoring its aggressive nature and poor prognosis [1]. Histologically, lung cancer is classified into two major subtypes: non-small cell lung cancer (NSCLC), which constitutes about 85% of cases, and small cell lung cancer (SCLC), comprising the remaining 15% [2]. Despite advancements in therapeutic strategies, the five-year survival rate for lung cancer remains low, largely due to late-stage diagnosis [3]. Therefore, early and accurate detection is crucial for improving patient survival and clinical outcomes.

Effective diagnosis of lung cancer relies on a combination of imaging techniques and histopathologic evaluation [4]. Among available tech-

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niques, endobronchial ultrasound-guided transbronchial needle aspiration (EBUS-TBNA) has emerged as a minimally invasive and highly accurate approach for assessing mediastinal lymphadenopathy and staging lung cancer [5]. By enabling direct sampling of hilar and mediastinal lymph nodes, EBUS-TBNA facilitates comprehensive malignancy evaluation with minimal patient discomfort [6]. Despite its widespread clinical adoption, diagnostic accuracy varies and is influenced by patient characteristics, lesion properties, and procedural factors [7]. However, the interplay among these factors remains incompletely understood, highlighting the need for further investigation [8].

Addressing these knowledge gaps is critical for enhancing the diagnostic performance of EBUS-TBNA and refining clinical decision-making [9]. A deeper understanding of the variables affecting biopsy success rates could enable clinicians to refine procedural protocols, reduce false-negative rates, and ultimately improve patient outcomes. This study aims to comprehensively analyze several determinants of EBUS-TBNA's diagnostic accuracy.

Materials and methods

Case selection

Inclusion and exclusion criteria: Patients were enrolled in this study based on the following inclusion criteria: (1) Presence of a primary lesion or enlarged lymph nodes adjacent to the trachea or bronchi, as detected by computerized tomography (CT); (2) Positive pathological confirmation obtained through EBUS-TBNA, bronchoscopy with direct biopsy, or surgical intervention, with all patients undergoing EBUS-TBNA; (3) Sampled lymph nodes with the shortest diameter exceeding 1 cm and exhibiting loss of central lymph node architecture; (4) Age ≥ 18 years.

Exclusion criteria included: (1) History of cerebrovascular disease; (2) Presence of concomitant pulmonary lesions; (3) Poor compliance due to vision or hearing impairment; and (4) Incomplete medical records. This study was approved by the Ethics Committee of Gaozhou People's Hospital.

Grouping criteria: This retrospective case-control study included lung cancer patients diagnosed at Gaozhou People's Hospital between October 2021 and September 2023. Patients with lung cancer confirmed by EBUS-TBNA, bronchoscopy with direct biopsy, or surgical intervention were re-evaluated using EBUS-TBNA. Based on the accuracy of the positive results, patients were placed into an Accurate Group (n = 204) and an Inaccurate Group (n = 41). An external validation cohort of 58 lung cancer patients was concurrently included. These patients were also divided into an Accurate Group (n = 51) and an Inaccurate Group (n = 7) based on diagnostic accuracy.

Intervention method

EBUS-TBNA procedure: The equipment utilized in this study included the endoscopic host GIF-H260 (Olympus, Japan), the ultrasound system Eu-ME2 (Olympus, Japan), the bronchoscope BF-260 (Olympus, Japan), the ultrasound bronchoscope BF-TYPE-UC260FW-772056 (Olympus, Japan), and the aspiration needle NA201 SX-4022 (Olympus, Japan). On the day of the procedure, patients fasted and were placed in a supine position. Continuous cardiac monitoring and supplemental oxygen were administered, and a laryngeal mask airway was inserted. Intravenous propofol was administered at a rate of 3-6 mg/kg/h for sedation, with additional intravenous analgesia provided as needed to ensure a pain-free experience. The procedure commenced with a sequential examination of the trachea, carina, and major bronchi to assess intraluminal conditions. After clearing respiratory secretions, an ultrasound bronchoscope was introduced, and the water balloon was inflated as necessary to optimize ultrasound imaging of CT-suspected lesions or enlarged lymph nodes. Lesion dimensions were measured, and their proximity to adjacent blood vessels was assessed to evaluate internal blood supply and determine the optimal puncture site. Under real-time ultrasound guidance, a puncture biopsy was performed using a needle connected to a 20 mL negative pressure syringe. The needle was maneuvered back and forth within the tissue several times to obtain an adequate histological sample. Based on the tissue yield from the same site, 1-3 puncture attempts were made at the clinician's discretion until a sufficient sample was obtained. After retracting the needle, the collected specimens were sent for pathologic exami-

Table 1. Comparison of general data between the two groups

Variable	Accurate group (n = 204)	Inaccurate group (n = 41)	t/χ^2	P
Age	60.26 ± 4.67	61.49 ± 4.18	1.574	0.117
Gender (Male/Female)	143 (70.1%)/61 (29.9%)	24 (58.54%)/17 (41.46%)	2.103	0.147
Smoking history	163 (79.9%)/41 (20.1%)	17 (41.46%)/24 (58.54%)	25.878	< 0.001
Methods of seeking medical care			1.252	0.263
Outpatient Department	114 (55.88%)	19 (46.34%)		
Hospitalization	90 (44.12%)	22 (53.66%)		
Pathologic diagnosis			13.925	< 0.001
Squamous cell carcinoma	79 (38.73%)	9 (21.95%)		
Adenocarcinoma	82 (40.2%)	12 (29.27%)		
Small cell lung cancer	43 (21.08%)	20 (48.78%)		
Pathologic staging			1.261	0.739
Stage I-II	17 (8.33%)	5 (12.2%)		
Stage IIIa	137 (67.16%)	24 (58.54%)		
Stage IIIb	33 (16.18%)	8 (19.51%)		
Stage IV	17 (8.33%)	4 (9.76%)		

nation. Hemostasis at the puncture site was ensured, and patients were transferred back to the ward upon stabilization.

Sample processing: Histological examination: The aspirated material within the puncture needle was expelled into a test tube containing 10% neutral buffered formalin for fixation. The samples underwent centrifugation, fixation, dehydration, and paraffin embedding before being sectioned. Hematoxylin and eosin (H&E) staining was then performed, and the specimens were examined under an optical microscope for histopathologic assessment.

Data collection

Patient demographic information was retrieved from the electronic medical record system. The collected variables included age, gender, smoking history, mode of presentation, pathologic diagnosis, and staging. Key procedural findings related to EBUS-TBNA were also recorded, including lesions or lymph node diameter, puncture sample characteristics, and the anesthesia methods used. Additionally, the results of lymph node punctures were documented, detailing the number of puncture attempts per lymph node station.

Statistical methods

All statistical analyses were performed using SPSS Statistics version 29.0 (SPSS Inc., Chicago, IL, USA). Categorical variables were presented as frequencies and percentages [n (%)]. The normality of continuous variables was assessed using the Shapiro-Wilk test. For normally distributed continuous variables, data were expressed as mean ± standard deviation (SD), and group comparisons were performed using a corrected variance t-test. A two-tailed *p*-value < 0.05 was considered significant.

Variables exhibiting significant differences in both comparative and correlation analyses, including smoking history, pathologic diagnosis, lesion and lymph node diameter, and puncture sample characteristics, were included as covariates for logistic regression analysis. Additionally, the predictive performance of these combined factors in assessing the risk of lung cancer recurrence was assessed using the area under the receiver operating characteristic (ROC) curve (AUC).

Results

Comparison of general characteristics between the two groups

This study analyzed the differences between the accurate and inaccurate groups regarding factors influencing the detection rate of lung cancer using EBUS-TBNA (**Table 1**). Representative histologic findings from H&E staining are shown in **Figure 1**. The mean age was 60.26 ± 4.67 years in the accurate group and

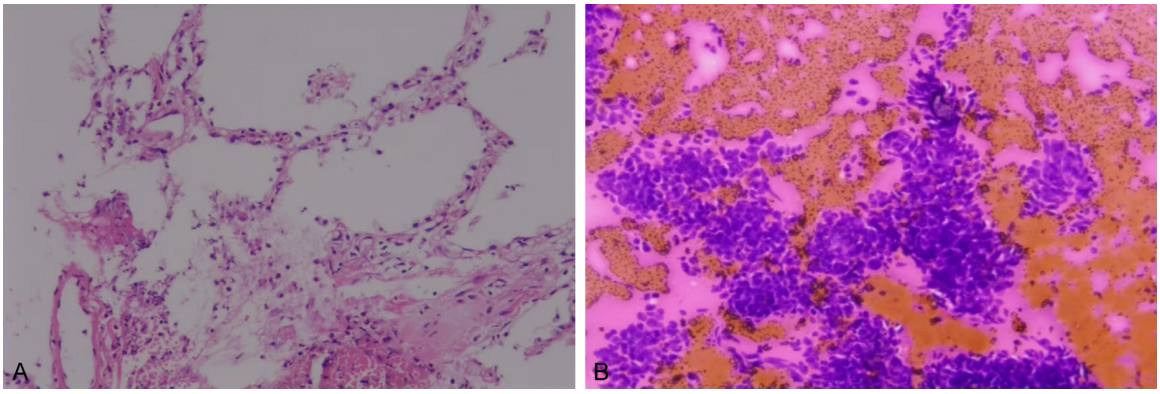

Figure 1. EBUS-TBNA histologic examination with H&E staining. A. Normal tissue; B. Lung cancer tissue. EBUS-TBNA: Endobronchial ultrasound-guided transbronchial needle aspiration.

61.49 ± 4.18 years in the inaccurate group, with no significant difference (P = 0.117). Gender distribution was also comparable between the two groups, with males accounting for 70.1% in the accurate group and 58.5% in the inaccurate group (P = 0.147). However, a significant difference was observed in smoking history: 79.9% of patients in the accurate group had a history of smoking, compared to only 41.5% in the inaccurate group (P < 0.001). The mode of seeking medical care did not significantly differ between groups (P = 0.263). In contrast, pathologic diagnosis showed a significant disparity, with SCLC more prevalent in the inaccurate group (48.8%) than in the accurate group (21.1%) (P < 0.001). No significant difference was observed in pathological staging distribution between the two groups (P = 0.739). These findings suggest that smoking history and pathologic subtype, particularly SCLC, are significant factors influencing the detection accuracy of EBUS-TBNA for lung cancer.

EBUS-TBNA-related findings

Analysis of EBUS-TBNA procedural findings revealed significant differences between the accurate and inaccurate groups (**Table 2**). Lesion or lymph node diameter was a key difference: in the accurate group, 50.0% of lesions measured ≥ 3 cm, whereas only 19.5% in the inaccurate group met this threshold (P < 0.001). In contrast, 80.49% of lesions in the inaccurate group were < 3 cm, highlighting the critical role of lesion size for diagnostic success. Furthermore, aspirate sample characteristics differed significantly between groups. Linear filamentous structures were observed in 72.1% of samples from the accurate group, whereas fragmented debris-like material predominated in the inaccurate group (78.1%) (P < 0.001). The type of anesthesia did not show a significant difference, with painless anesthesia administered in 96.1% of cases in the accurate group and 95.1% in the inaccurate group (P = 1). These results suggest that larger lesion sizes and specific cytologic features of aspirate samples were strongly associated with higher diagnostic accuracy.

Lymph node puncture findings

Significant differences were also identified in lymph node puncture findings between the two groups (**Table 3**). The number of punctured lymph node stations was higher in the accurate group, with 46.57% of patients undergoing biopsy of avilymph node stations, compared to only 21.95% in the inaccurate group (P = 0.004). Additionally, the frequency of punctures per lymph node station was significantly greater in the accurate group: 69.12% of patients in the accurate group underwent puncture ≥ 3 times, whereas only 36.59% in the inaccurate group met this criterion (P < 0.001). Thus, both an increased number of sampled lymph node stations and a higher puncture frequency per station were associated with improved diagnostic accuracy.

Multivariate logistic regression analysis

Multivariable logistic regression analysis identified several significant factors influencing the likelihood of inaccurate lung cancer detection by EBUS-TBNA (**Table 4**). Smoking history was

Table 2. EBUS-TBNA-related indices

Variable	Accurate group (n = 204)	Inaccurate group (n = 41)	t/χ^2	P
Diameter of lesion or lymph node (cm)			12.826	< 0.001
≥ 3 cm	102 (50%)	8 (19.51%)		
< 3 cm	102 (50%)	33 (80.49%)		
Characteristics of the aspirate sample			37.057	< 0.001
Linear filamentous changes	147 (72.06%)	9 (21.95%)		
Fragmented debris-like changes	57 (27.94%)	32 (78.05%)		
Anesthesia method			0.000	1.000
Local anesthesia	8 (3.92%)	2 (4.88%)		
Painless	196 (96.08%)	39 (95.12%)		

EBUS-TBNA: Endobronchial ultrasound-guided transbronchial needle aspiration.

Table 3. Lymph node puncture indices

Variable	Accurate group (n = 204)	Inaccurate group (n = 41)	t/χ^2	P
Number of lymph node puncture groups			8.469	0.004
≥ 2 groups	95 (46.57%)	9 (21.95%)		
< 2 groups	109 (53.43%)	32 (78.05%)		
Number of lymph node punctures per group			15.620	< 0.001
≥ 3 times	141 (69.12%)	15 (36.59%)		
< 3 times	63 (30.88%)	26 (63.41%)		

Table 4. Multivariate logistic regression analysis of factors influencing inaccurate detection of lung cancer by EBUS-TBNA

Variable	Coefficient	Std Error	Wald Stat	OR	OR CI Lower	OR CI Upper	*P* Value
Smoking history	2.073	0.458	4.523	7.948	3.237	19.516	< 0.001
Squamous cell carcinoma	-0.350	0.552	-0.634	0.705	0.239	2.080	0.526
Small cell lung cancer	1.385	0.510	2.718	3.996	1.471	10.854	0.007
Diameter of lesion or lymph node ≥ 3 cm	-1.069	0.480	-2.227	0.343	0.134	0.880	0.026
Presence of linear filamentous changes in aspirate sample	-2.248	0.471	-4.774	0.106	0.042	0.266	< 0.001

strongly associated with higher risk of inaccurate detection, with an odds ratio (OR) of 7.948 (95% CI, 3.237-19.516; $P < 0.001$). Similarly, SCLC was a significant predictor of inaccurate detection (OR, 3.996; 95% CI, 1.471-10.854; $P = 0.007$). Conversely, a lesion or lymph node diameter of ≥ 3 cm was significantly associated with a reduced risk of inaccurate detection (OR, 0.343; 95% CI, 0.134-0.880; $P = 0.026$). Additionally, the presence of linear filamentous structures in the aspirate sample was a strong factor protecting against inaccurate detection (OR, 0.106; 95% CI, 0.042-0.266; $P < 0.001$). Notably, squamous cell carcinoma did not show a significant effect on detection accuracy ($P = 0.526$). These results underscore the critical role of smoking history and pathologic subtypes, particularly SCLC, in contributing to diagnostic accuracy. In contrast, larger lesion sizes and specific cytologic features of aspirate samples were associated with improved detection accuracy.

ROC analysis of independent predictors for inaccurate lung cancer detection by EBUS-TBNA

ROC analysis was conducted to assess the predictive performance of independent risk factors for inaccurate lung cancer detection by EBUS-TBNA (**Figure 2**). Among all factors, aspirate sample characteristics exhibited the highest discriminative ability, with an AUC of 0.751,

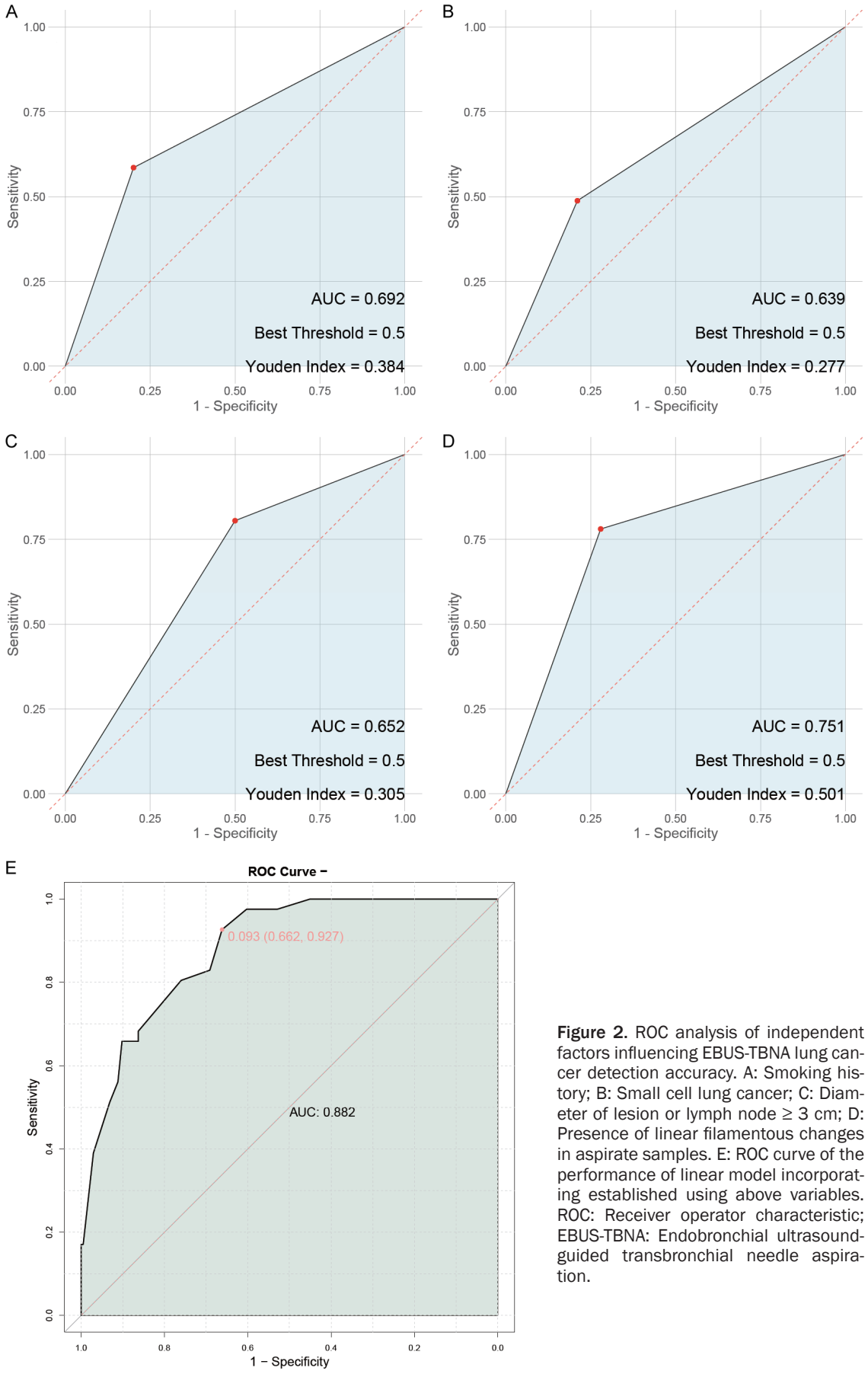

Figure 2. ROC analysis of independent factors influencing EBUS-TBNA lung cancer detection accuracy. A: Smoking history; B: Small cell lung cancer; C: Diameter of lesion or lymph node ≥ 3 cm; D: Presence of linear filamentous changes in aspirate samples. E: ROC curve of the performance of linear model incorporating established using above variables. ROC: Receiver operator characteristic; EBUS-TBNA: Endobronchial ultrasound-guided transbronchial needle aspiration.

Table 5. General characteristics of patients for external validation

Variable	Accurate group (n = 51)	Inaccurate group (n = 7)	t/χ^2	P
Age	61.74 ± 5.08	60.22 ± 4.58	0.747	0.458
Gender (Male/Female)	35 (68.63%)/16 (31.37%)	4 (57.14%)/3 (42.86%)	0.032	0.859
Smoking history	41 (80.39%)/10 (19.61%)	2 (28.57%)/5 (71.43%)	6.130	0.013
Methods of seeking medical care			0.038	0.845
Outpatient Department	28 (54.9%)	3 (42.86%)		
Hospitalization	23 (45.1%)	4 (57.14%)		
Pathologic diagnosis			6.602	0.037
Squamous cell carcinoma	22 (43.14%)	2 (28.57%)		
Adenocarcinoma	21 (41.18%)	1 (14.29%)		
Small cell lung cancer	8 (15.69%)	4 (57.14%)		
Pathologic staging			None	0.666
Stage I-II	4 (7.84%)	1 (14.29%)		
Stage IIIa	34 (66.67%)	4 (57.14%)		
Stage IIIb	9 (17.65%)	1 (14.29%)		
Stage IV	4 (7.84%)	1 (14.29%)		

a sensitivity of 0.78, a specificity of 0.721, a Youden index of 0.501, and an F1 score of 0.091. Smoking history also demonstrated a strong predictive value, with an AUC of 0.692, a sensitivity of 0.585, and a specificity of 0.799, yielding a Youden index of 0.384 and an F1 score of 0.453. The diameter of the lesion or lymph node showed high sensitivity (0.805) but lower specificity (0.500), with an AUC of 0.652, a Youden index of 0.305, and an F1 score of 0.106. SCLC exhibited an AUC of 0.639, with a sensitivity of 0.488 and a specificity of 0.789, resulting in a Youden index of 0.277 and an F1 score of 0.385. To enhance predictive accuracy, we established a generalized linear model incorporating these independent variables. The combined predictive model demonstrated superior performance, achieving an AUC of 0.882, a specificity of 0.662, and a sensitivity of 0.927, indicating strong discriminatory power for inaccurate detection.

General characteristics of patients in the external validation cohort

The analysis of general patient characteristics in the external validation cohort revealed significant differences in smoking history and pathologic diagnosis between the accurate and inaccurate detection groups (**Table 5**). The prevalence of smoking was significantly higher in the accurate group, with 80.39% having a history of smoking compared to 28.57% in the inaccurate group ($P = 0.013$). In terms of pathologic diagnosis, the accurate group was predominantly composed of patients with squamous cell carcinoma (43.14%) or adenocarcinoma (41.18%), whereas the inaccurate group had a higher proportion of SCLC (57.14%) ($P = 0.037$). No significant differences were observed between the two groups in terms of age, gender, medical care-seeking method, or pathologic staging (all $P > 0.05$). These findings from the external validation cohort reinforce the significance of smoking history and specific cancer subtype in determining detection accuracy.

EBUS-TBNA-related indices in the external validation cohort

In the external validation cohort, significant differences in EBUS-TBNA-related indices were observed between the accurate and inaccurate detection groups (**Table 6**). Lesion or lymph node size was a key distinguishing factor; 66.67% of patients in the accurate group had lesions measuring ≥ 3 cm, compared to only 14.29% in the inaccurate group ($P = 0.025$). Additionally, aspirate sample characteristics were significantly associated with detection accuracy. Linear filamentous structures were present in 74.51% of accurately detected cases, whereas fragmented debris-like changes were more common in the inaccurate group, observed in 71.43% of cases ($P = 0.043$). Thus,

Table 6. EBUS-TBNA-related indices in the external validation cohort

Variable	Accurate group (n = 51)	Inaccurate group (n = 7)	t/χ^2	P
Diameter of lesion or lymph node (cm)			5.038	0.025
≥ 3 cm	34 (66.67%)	1 (14.29%)		
< 3 cm	17 (33.33%)	6 (85.71%)		
Characteristics of the aspirate sample			4.112	0.043
Linear filamentous changes	38 (74.51%)	2 (28.57%)		
Fragmented debris-like changes	13 (25.49%)	5 (71.43%)		

EBUS-TBNA: Endobronchial ultrasound-guided transbronchial needle aspiration.

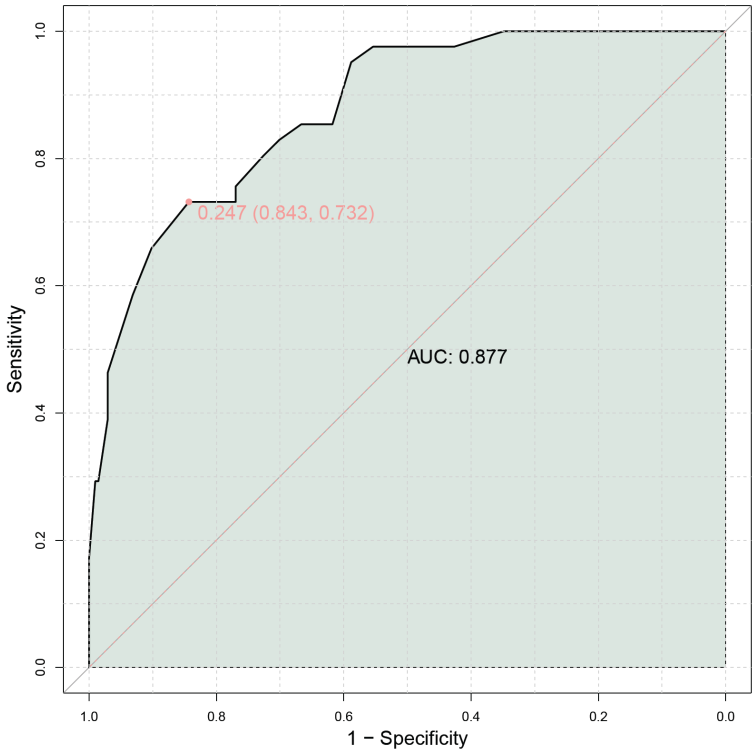

Figure 3. ROC curve of the joint predictive model in the external validation cohort.

lesion size and aspirate sample characteristics were critical for diagnostic accuracy.

ROC curve analysis of the joint predictive model in the external validation cohort

ROC analysis was performed to assess the performance of the joint predictive model, which was established based on independent predictors of inaccurate lung cancer detection by EBUS-TBNA (**Figure 3**). The model demonstrated strong predictive performance, with an AUC of 0.877, a specificity of 0.843, and a sensitivity of 0.732. These findings indicate a high robustness of the model.

Discussion

This study identified several key factors influencing the accuracy of lung cancer detection by EBUS-TBNA, including smoking history, lesion size, pathologic diagnosis, and aspirate sample characteristics. These findings underscore the need for further investigation into the underlying mechanisms driving these associations.

Smoking history emerged as a critical factor associated with detection accuracy, demonstrating a strong correlation with inaccurate diagnosis. This association may be attributed to the histopathologic and biological changes induced by smoking, which can alter tissue characteristics and obscure malignant lesions [10]. Smoking has been well-documented to cause a spectrum of histopathologic alterations in lung tissue, possibly masking malignant cells and rendering cancer more delitescent, thereby complicating its detection by EBUS-TBNA [11]. Furthermore, chronic inflammation resulting from smoking can lead to structural modifications in bronchial tissue, making it more challenging to obtain sufficient representative samples using a puncture needle. This, in turn, increases the likelihood of false-negative results [12]. Given these findings, smoking history significantly affects the diagnostic accuracy of EBUS-TBNA by modifying tissue properties which raises the risk of false-negative results.

Pathologic diagnosis also played a crucial role in detection accuracy, particularly in cases of SCLC, which exhibited a higher prevalence in inaccurate diagnoses. The inherent characteristics of SCLC - including its rapid proliferation, diffuse infiltration, and early metastatic potential - pose significant challenges for obtaining adequate aspirate samples that accurately represent the primary tumor [13, 14]. Moreover, the aggressive nature of SCLC and its propensity for microscopic dissemination beyond the biopsied lymph nodes may lead to discrepancies between clinical and pathologic findings, further contributing to diagnostic inaccuracy [15]. The high cellular density and compact nature of SCLC tumors may also impede the collection of sufficient cytologic material and lead to false-negatives [16]. These findings highlight the unique diagnostic challenges posed by SCLC, emphasizing the need for optimized biopsy strategies to improve detection accuracy with EBUS-TBNA.

The study underscores the significant role of lesion or lymph node size in influencing the accuracy of lung cancer detection. Larger lesions were associated with higher detection accuracy, likely due to the more accessible sampling that larger, anatomically well-defined targets provide [17]. In contrast, smaller lesions are often more challenging to identify and puncture accurately, resulting in inadequate sampling [18]. Additionally, larger lesions may cause greater distortion of normal tissue architecture, facilitating the differentiation of malignant from normal or inflammatory tissues during microscopic examination [19]. Moreover, larger tumors often exhibit increased vascularity or necrosis, which can further aid in distinguishing malignancy based on these histologic characteristics [20]. In summary, larger lesion size enhances the accuracy of EBUS-TBNA by providing more accessible targets for sampling.

The characteristics of aspirate samples, particularly linear filamentous changes, were positively correlated with detection accuracy. These morphologic features likely signify a more organized and cohesive cellular architecture typical of malignancy, in contrast to the fragmented, debris-like appearance commonly seen in non-malignant or poorly aspirated tissue samples [21, 22]. The preserved histologic integrity in linear filamentous structures likely provides clearer evidence of pathologic aberrations, thereby aiding in accurate diagnosis [23]. This highlights the importance of carefully evaluating the aspiration technique to ensure the optimal collection of representative tissue samples during EBUS-TBNA.

The lack of significant differences in detection accuracy related to the anesthesia method emphasizes the procedural robustness of EBUS-TBNA. Despite the predominant use of local anesthesia, which is a standard practice in many clinical settings, the accuracy was not compromised [24, 25]. This suggests that EBUS-TBNA can be effectively performed with minimal sedation, ensuring patient safety and comfort while maintaining diagnostic efficacy. In summary, the choice of anesthesia method did not significantly impact the accuracy of EBUS-TBNA.

The logistic regression analysis further solidifies the role of smoking history, SCLC pathology, and lesion size as critical factors influencing detection accuracy. These findings advocate for the integration of comprehensive patient history and precise imaging prior to EBUS-TBNA, which may optimize sampling strategy and enhance diagnostic yield. Clinicians should exercise particular caution when interpreting results from individuals with a long smoking history or a clinical suspicion of SCLC, where alternative or adjunctive diagnostic strategies may be necessary. Logistic regression analysis confirmed the critical role of smoking history, SCLC pathology, and lesion size in detection accuracy, emphasizing the need for tailored diagnostic approaches.

ROC analysis of the joint predictive model highlights its use in clinical settings, offering a robust approach to enhance diagnostic efficiency in EBUS-TBNA procedures. By incorporating key variables that significantly affect detection accuracy, the joint prediction assists in clinical decision-making, enabling personalized procedural adjustments to minimize inaccurate results. The practical implementation of such predictive models should transform individualized diagnostic strategies, facilitating the early and accurate detection of lung cancer, which is crucial for timely therapeutic intervention.

While this study provides valuable insight into the factors affecting lung cancer detection rates by EBUS-TBNA, it is not without limitations. First, being a retrospective analysis, it may be subject to inherent bias associated with data collection and incomplete clinical records. The reliance on smoking history as a binary variable also fails to capture the complexity of its cumulative effects, such as smoking duration and cessation status, which could differentially affect diagnostic accuracy. Additionally, the technical variations in EBUS-TBNA procedures among different practitioners may introduce variability that was not accounted for in this analysis. Another limitation of this study is its relatively small sample size. Although our findings provide valuable insight into the factors influencing lung cancer detection rates through EBUS-TBNA biopsy, the limited number of participants may have affected the generalizability of the results. A larger sample size would enhance statistical power and enable a more robust analysis, particularly in detecting subtle differences in diagnostic performance across subgroups, such as those defined by lesion size or smoking history. Future studies with larger cohorts are warranted to validate these findings.

Conclusion

This study identified critical factors influencing the detection accuracy of lung cancer through EBUS-TBNA, offering insight for procedural optimization. The identified factors underscore the importance of a comprehensive understanding of patient history and lesion characteristics to enhance biopsy yield and diagnostic reliability. Future research should focus on refining aspiration techniques and exploring complementary diagnostic tools to overcome challenges in detecting small lesions or complex histologic patterns, particularly in smoking-associated lung cancers. Ultimately, integrating these findings into clinical practice should substantially improve outcomes.

Disclosure of conflict of interest

None.

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