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DIAGNOSTIC UTILITY OF LINEAR EBUS-TBNA IN CENTRALLY LOCATED LUNG TUMORS AND MEDIASTINAL LYMPHADENOPATHY

Dr Sarthak Jindal[1*], Dr Mahesh Kumar Mahich[2], Dr Neha Damor[2], Dr Mahendra Kumar Bainara[3], Dr Archana MK[1], Dr Nemi Chand Garg[1], Dr Jatin Prajapati[4]

[1*] Post Graduate Student, Department of Respiratory Medicine, RNT Medical College, Udaipur, Rajasthan, India
[2] Assistant Professor, Department of Respiratory Medicine, RNT Medical College, Udaipur, Rajasthan, India
[3] Senior Professor, Department of Respiratory Medicine, RNT Medical College, Udaipur, Rajasthan, India
[4] Senior Resident, Department of Community Medicine, World College of Medical Sciences and Research, Jhajjar, Haryana, India, ORCID: https://orcid.org/0009-0004-7298-4499

***Corresponding Author:** Dr Sarthak Jindal
*House no. 7, Shantipuram, Jhansa Road, Thanesar, Kurukshetra, Haryana (PIN- 136118)
Email ID: saarthakjindal1997@gmail.com,

ABSTRACT

Background: Centrally located lung tumors and mediastinal lymphadenopathy pose diagnostic challenges, especially when conventional bronchoscopy yields inadequate samples. Linear endobronchial ultrasound-guided transbronchial needle aspiration (EBUS-TBNA) enables real-time sampling of mediastinal and hilar lymph nodes with high diagnostic accuracy. This study evaluates the diagnostic performance, staging utility, and safety of linear EBUS-TBNA in patients with central lung lesions and mediastinal lymphadenopathy.

Methods: A hospital-based cross-sectional observational study was conducted over five months in the Department of Respiratory Medicine, TB & Chest Hospital, Udaipur. A total of 38 patients ≥18 years with centrally located lung tumors or mediastinal lymphadenopathy were enrolled. Patients underwent clinical evaluation, chest radiography, CECT thorax, fibreoptic bronchoscopy, and EBUS-TBNA. Data on demographics, clinical features, radiology, lymph node characteristics, sampling details, histopathology, and complications were analyzed. Diagnostic performance was calculated using sensitivity, specificity, and predictive values. Statistical significance was set at $p < 0.05$.

Results: Of the 38 patients, 30 were diagnosed with lung carcinoma (24 NSCLC, 6 SCC). The mean age was 63.23 years, and 76.7% were male. Cough (83.3%), hemoptysis (53.3%), and weight loss (53.3%) were the most common symptoms. CECT most frequently identified masses in the right lower lobe (20%), while mediastinal nodes were common at stations 7 (23.3%) and 10R (20%). EBUS-TBNA most frequently sampled station 7 (23.3%). Single-node sampling was performed in 63.3% of cases. Histopathology confirmed NSCLC in 80% and SCC in 20%. EBUS-TBNA demonstrated a diagnostic yield of 84.2%, significantly higher than bronchoscopy (21.1%). Sensitivity, specificity, PPV, and NPV for diagnosing malignancy were 88.8%, 100%, 100%, and 33.3%, respectively. Most patients presented in stage IIIA/IIIB (63.3%). Procedure-related

complications were minimal (16.6%), consisting mainly of minor bleeding and mild desaturation, with no major adverse events.
Conclusion: Linear EBUS-TBNA is a highly effective and safe diagnostic modality for centrally located lung tumors and mediastinal lymphadenopathy, offering superior diagnostic yield over bronchoscopy. Its ability to provide simultaneous diagnosis and staging supports its role as a first-line invasive investigation in lung cancer evaluation.

Keywords: Linear EBUS-TBNA, Centrally located lung tumors, Mediastinal lymphadenopathy, Lung cancer diagnosis, Mediastinal staging, Endobronchial ultrasound, Diagnostic yield

INTRODUCTION

Lung cancer remains the leading cause of cancer-related mortality worldwide and poses a major global health challenge due to its late presentation, aggressive nature, and limited treatment options in advanced stages. Histologically, lung cancer is broadly classified into non–small cell lung cancer (NSCLC) and small-cell lung cancer (SCLC). NSCLC constitutes the majority of cases and includes three main subtypes: adenocarcinoma (ADC), squamous cell carcinoma (SCC), and large-cell carcinoma (LCC). Adenocarcinoma is the most frequently encountered type and typically arises in the peripheral regions of the lungs, although central variants are increasingly recognized. It is seen more commonly in women and non-smokers. Squamous cell carcinoma usually originates in central airways and has a strong association with smoking, though in recent years a shift toward peripheral locations has been reported. Large-cell carcinoma, although the least common, may occur anywhere in the lung and is characterized by rapid growth and early dissemination. SCLC, although less prevalent than NSCLC, represents an aggressive neuroendocrine tumor strongly linked to smoking, with a propensity for early metastasis and rapid progression. Traditionally described as centrally located, SCLC may also arise in peripheral lung tissue.
Accurate diagnosis and staging are essential for guiding the management of lung cancer. Establishing a histological diagnosis requires tissue sampling, typically obtained using transthoracic needle aspiration (TTNA), transbronchial needle aspiration (TBNA), or transbronchial biopsies. While these conventional approaches remain widely used, technological advancements have introduced modern modalities such as CT-guided bronchoscopy, virtual bronchoscopy, electromagnetic navigation bronchoscopy, and endobronchial ultrasound (EBUS), all aimed at improving diagnostic yield and procedural safety. However, these specialized approaches remain limited to high-volume or tertiary-care centers due to resource constraints and technical expertise requirements[1].
For centrally located lung tumors, clinical guidelines recommend flexible bronchoscopy with biopsy or TBNA as the initial diagnostic modality. Despite being the first-line approach, bronchoscopy often yields inadequate samples, especially in cases lacking visible endobronchial lesions. CT-guided TTNA serves as an alternative option, but in centrally located lesions it poses higher procedural risks including pneumothorax and hemorrhage[2]. Furthermore, central tumors are often difficult to access percutaneously due to anatomical constraints, resulting in lower diagnostic success than that achieved with peripheral lesions[3,4]. For mediastinal lymph node staging, current evidence-based guidelines recommend endobronchial ultrasound (EBUS) and endoscopic ultrasound using the EBUS bronchoscope (EUS-B) as the preferred techniques. In cases where CT identifies a centrally located mass adjacent to major airways and bronchoscopy remains non-diagnostic, endobronchial ultrasound-guided transbronchial needle aspiration (EBUS-TBNA) is considered the investigation of choice[5,6].

Linear EBUS-TBNA has emerged as a cornerstone technique in both the diagnosis and mediastinal staging of lung cancer. It is minimally invasive and enables real-time ultrasound-guided sampling of mediastinal and hilar lymph nodes as well as select parenchymal lesions[7]. Numerous studies have demonstrated that EBUS-TBNA is accurate, safe, and cost-effective, with diagnostic accuracy comparable to mediastinoscopy. Meta-analyses have reported high sensitivity and specificity for mediastinal staging using EBUS, reaching values equivalent to cervical mediastinoscopy[8].

Consequently, the American College of Chest Physicians (ACCP) recommends EBUS-TBNA as a first-line invasive modality for mediastinal staging of lung cancer[9].

The International Association for the Study of Lung Cancer (IASLC) classifies mediastinal and hilar lymph nodes into stations (1–14) based on anatomical location[10]. Accurate identification of lymph node stations is critical for staging, determining prognosis, and guiding therapeutic decisions. Linear EBUS allows the assessment of stations 2R, 2L, 3P, 4R, 4L, 7, 10R, 10L, 11R, and 11L, with high diagnostic yield even in small lymph nodes measuring 5–10 mm. A meta-analysis of 11 studies involving 1,299 patients reported a sensitivity of 93% and a specificity of 100% for mediastinal staging using EBUS-TBNA[11].

EBUS-TBNA permits diagnosis and staging in a single procedure. Optimal staging requires systematic sampling beginning with N3 lymph nodes, progressing to N2, and concluding with N1 nodes. This approach minimizes the risk of cross-contamination and upstaging. Importantly, all lymph node stations should be assessed irrespective of PET-CT findings. Herth et al. demonstrated that EBUS-TBNA identified occult nodal metastases in 9 out of 97 NSCLC patients who had no radiologic evidence of mediastinal involvement on CT or PET-CT[12]. Using a single needle for sequential sampling is acceptable if the correct nodal order (N3 → N2 → N1) is maintained; sampling lower-order stations first risks contamination and false upstaging[13]. Although a separate needle for each station eliminates this risk, the cost increases significantly[14].

EBUS-TBNA may be performed under general anesthesia, deep sedation, or moderate sedation. The oral route is commonly preferred, but several studies show that the nasal route is feasible and equally well tolerated, without compromising diagnostic yield or increasing complications[15].

Lymph node characterization using endobronchial ultrasonography is crucial for selecting nodes for aspiration. Sonographic features predictive of malignancy include round shape, distinct margins, heterogeneous echogenicity, coagulation necrosis sign, absence of central hilar structure, and increased vascularity. Fujiwara et al. first described these predictive characteristics in a large retrospective study of 1,061 lymph nodes[16]. Schmid-Bindert et al. later proposed a detailed predictive scoring system incorporating these features, with an observed malignancy risk of 80% when all six criteria were present[17].

EBUS-TBNA is generally considered safe, with a major complication rate of <1%. Minor issues such as cough, restlessness, and minimal bleeding at the puncture site are common. Rare but serious complications—mediastinitis, pericarditis, and pneumothorax—have been reported[18–20]. Diagnostic adequacy increases with the number of needle passes. Lee et al. reported sample adequacy rates of 90.1%, 98.1%, and 100% after one, two, and three passes, respectively, with no significant improvement beyond three passes[21]. Rapid onsite evaluation (ROSE) has been shown to reduce the number of passes and the need for additional procedures[15]. Needle size (21G vs 22G) does not significantly influence diagnostic accuracy, as demonstrated by Nakajima et al.[22].

Given the increasing reliance on minimally invasive diagnostic modalities, the present study aims to evaluate the diagnostic utility and staging performance of linear EBUS among patients with centrally located lung tumors and mediastinal lymphadenopathy.

MATERIALS AND METHODS

Study Design: Hospital-based cross-sectional observational study.

Study Setting: Department of Respiratory Medicine, TB & Chest Hospital, Badi, Udaipur, Rajasthan, affiliated with R.N.T. Medical College, Udaipur.

Study Duration: 5 months (June 2025 to October 2025)

Study Population: Patients attending OPD/IPD with centrally located lung tumors and/or mediastinal lymphadenopathy who met the eligibility criteria and provided informed consent.

Inclusion Criteria
- Adults aged ≥18 years
- CT-detected central lung tumors (lesions adjacent to trachea, main bronchus, or segmental bronchi)[13]
- Mediastinal lymphadenopathy with or without lung mass
- Willingness to give informed consent

Exclusion Criteria
- Refusal or withdrawal of consent
- Previously diagnosed benign diseases (e.g., tuberculosis, sarcoidosis)
- Hemodynamically unstable or moribund patients
- Poor performance status

Sample Size: Minimum 38 patients, calculated using the formula

$$N = \frac{Z^2 P(1-P)}{C^2}$$

based on Verma A et al.[1], with Z = 1.96, P = 1.3%, C = 20%.

Methodology for Data Collection: Data were collected using a structured proforma including demographic details, clinical history, comorbidities, TB screening (AFB, CBNAAT, Tuberculin test), radiological findings (X-ray, CECT thorax), fibreoptic bronchoscopy (FOB) observations, and EBUS-TBNA results (cytology and histopathology).

Study Procedure

1. Clinical Evaluation: Detailed history, physical examination, respiratory assessment, and relevant investigations were performed for all enrolled patients.

2. Fibreoptic Bronchoscopy (FOB): FOB was carried out in the bronchoscopy suite and findings were documented.

3. Linear EBUS-TBNA
- Performed using a linear EBUS bronchoscope under conscious/moderate sedation.
- Pre-procedure nebulization with 2% xylocaine and topical/oropharyngeal lidocaine spray administered.
- Sedation provided using midazolam and fentanyl as required.
- Supplemental oxygen given; continuous monitoring performed.
- A 22-gauge TBNA needle introduced through the working channel.
- Real-time ultrasound guidance used to identify lymph nodes; Doppler employed to avoid vessels.
- Needle passes made for 20–30 seconds with suction.
- Air-dried smears prepared for cytology; tissue cores fixed in formalin for histopathology.
- Patients observed post-procedure until stable for discharge.

Variables Assessed
- Patient-related: age, sex, comorbidities, clinical profile
- Procedure-related: lymph node station, number of nodes sampled, number of passes, needle gauge, sample adequacy, sedation level, procedure duration
- Outcome-related: diagnostic yield, cytology/histopathology reports

Statistical Analysis: Data were analyzed using SPSS version 26. Descriptive statistics (mean, standard deviation, frequencies) were used to summarize patient and procedural characteristics. Diagnostic performance of EBUS-TBNA was assessed using sensitivity, specificity, positive and negative predictive values, and overall accuracy. Categorical variables were compared using the Chi-

square or Fisher's exact test, while continuous variables were analyzed with the t-test or Mann–Whitney U test as appropriate. A p-value <0.05 was considered statistically significant, with 95% confidence intervals calculated for key outcomes.

Ethical Considerations: The study was conducted after approval from the Institutional Ethics Committee of R.N.T. Medical College, Udaipur. Written informed consent was obtained from all participants prior to enrollment. Confidentiality was maintained throughout the study, and all procedures adhered to standard ethical guidelines for human research.
IEC Approval Number: RNT/Acad./Ethical/2025/702 dated 27/05/2025

RESULTS

A total of 38 participants underwent evaluation with bronchoscopy and EBUS-TBNA. Of these, 30 patients were diagnosed with lung carcinoma (24 NSCLC, 6 SCC), while 2 patients were diagnosed with pulmonary tuberculosis, and 6 had non-malignant findings. Results below describe the 30 lung carcinoma patients, as per study objectives.

Baseline and Clinical Characteristics

The mean age of participants was 63.23 ±10.97 years, with the majority (66.7%) aged >60 years. Males constituted 76.7% of cases. Most patients (63.3%) presented within 1–3 months of illness. The predominant symptoms included cough (83.3%), hemoptysis (53.3%), weight loss (53.3%), and dyspnea (36.6%). Comorbidities were present in 63.4% of patients, most commonly hypertension (16.6%) and cardiovascular disease (16.6%). History of smoking was seen in 73.3%, with most smokers having 20–40 pack years of exposure. Alcohol consumption was reported by 23.3%, and smokeless tobacco use by only 1 patient. History of prior tuberculosis was present in 6 (20%) NSCLC patients; none among SCC. Table 1 summarizes age, sex distribution, duration of illness, presenting complaints, addictions, and comorbidities.

Table 1. Baseline and Clinical Profile of Lung Cancer Patients (N = 30)

Variable	SCC (n=6)	NSCLC (n=24)	Total (N=30)
Age >60 years	83.3%	62.5%	66.7%
Male sex	83.3%	75.0%	76.7%
Illness duration 1–3 months	83.3%	58.3%	63.3%
Cough	83.3%	83.3%	83.3%
Hemoptysis	50.0%	54.1%	53.3%
Dyspnea	50.0%	33.3%	36.6%
Weight loss	50.0%	54.1%	53.3%
History of TB	0%	25%	20%
Smoking (Yes)	66.6%	75.0%	73.3%
Alcohol use	33.3%	20.8%	23.3%
Any NCD	83.3%	58.3%	63.4%

On chest X-ray, a right-sided mass was predominant (66.6%). The most frequent locations were right upper zone (26.6%), right lower zone (20%), and left upper zone (16.6%). CECT revealed the most common tumor locations as right lower lobe (20%), left upper lobe (16.6%), and right upper lobe (16.6%). The mean lesion size was 5.02 × 4.75 cm, with sizes ranging from 1.8 × 2.0 cm to 12 × 13 cm. Mediastinal lymphadenopathy was seen in all patients; the most common stations were station 7 (23.3%) and 10R (20%). The mean largest lymph node size was 2.55 × 2.11 cm. Pleural effusion was

present in 8/30 (26.6%), collapse in 6/30 (20%), and metastasis in 8/30 (26.6%), more frequently in SCC.(Table 2)

Table 2. Radiological Findings on X-ray and CECT (N = 30)

Radiological Feature	SCC (n=6)	NSCLC (n=24)	Total
Right-sided mass (X-ray)	83.3%	62.5%	66.6%
Most common X-ray location	RLZ (33.3%)	RUZ (29.1%)	RUZ (26.6%)
Most common CECT location	RLL (33.3%)	LUL/RLL/RUL (16.6% each)	RLL (20%)
Mean tumor size (cm)	4.35×3.98	5.19×1.94	5.02×4.75
Common LN stations	7 (33.3%)	10R/7 (20.8%)	7 (23.3%)
Mean LN size (cm)	1.93×1.45	2.21×2.28	2.55×2.11
Pleural effusion	50.0%	20.8%	26.6%
Collapse	16.6%	20.8%	20.0%
Metastasis	50.0%	20.8%	26.6%

The most commonly sampled lymph node station was station 7 (23.3%) followed by 10R (20%). Single-node sampling was performed in 63.3%, two nodes in 26.6%, and three nodes in 10%. Histopathology showed NSCLC in 80% and SCC in 20%. Among NSCLC cases, the most common subtype was squamous cell carcinoma (23.3%), followed by adenocarcinoma (46.6%) and LCC (6.66%).(Table 3)

Table 3. EBUS Findings Including Stations Sampled, Nodes Sampled & Histopathology (N = 30)

EBUS Parameter	SCC	NSCLC	Total
Most common LN station	7 (33.3%)	10R/7 (20.8%)	7 (23.3%)
Single node sampled	50.0%	66.6%	63.3%
Histopathology – SCC	6 (100%)	–	20%
Histopathology – Adeno	–	14 (46.6%)	46.6%
Histopathology – SQCC	–	7 (23.3%)	23.3%
Histopathology – LCC	–	2 (6.6%)	6.6%
Histopathology – NOS	–	1 (3.3%)	3.3%

According to TNM staging by EBUS, the most frequent stage was III B (33.3%), followed by III A (30%) and IV A (26.6%). SCC cases had higher metastatic burden, with 50% presenting as stage IV A.(Table 4)

Table 4. TNM Stage Grouping Based on EBUS Findings (N = 30)

Stage Group	SCC (n=6)	NSCLC (n=24)	Total

Table 4. TNM Stage Grouping Based on EBUS Findings (N = 30)

IIA	0%	4.1%	3.3%
IIB	0%	8.3%	6.6%
III A	33.3%	29.1%	30.0%
III B	16.6%	37.5%	33.3%
IV A	50.0%	20.8%	26.6%

Intra-procedural complications were observed in 5 patients (16.6%), predominantly minor bleeding (13.3%) and transient desaturation (3.3%). All occurred in NSCLC patients. Post-procedure complications were noted in 4 patients (13.3%), all presenting with mild hemoptysis. No major complications were recorded.(Table 5)

Table 5. EBUS Procedural and Post-procedural Complications (N = 30)

Complication	**SCC**	**NSCLC**	**Total**
Bleeding	0%	16.6%	13.3%
Low SpO_2	0%	4.1%	3.3%
Post-procedure hemoptysis	0%	16.7%	13.3%
No complication	100%	79.1%	86.7%

Diagnostic Performance of EBUS vs Bronchoscopy

EBUS-TBNA demonstrated a significantly higher diagnostic yield (84.2%) compared to bronchoscopy (21.1%). Among new cases, EBUS achieved 83.3% yield vs 16.6% for bronchoscopy. With suction, EBUS yield increased to 85.7%.

For malignancy:

- EBUS sensitivity: 88.8%
- Specificity: 100%
- PPV: 100%
- NPV: 33.3%

Overall sensitivity for diagnosing both benign and malignant etiologies was 84.2%.

These findings strongly support the diagnostic superiority of EBUS-TBNA over conventional bronchoscopy.

DISCUSSION

In the present study, most patients with lung carcinoma were older adults, with a mean age of 63.23 years. A higher proportion of patients with SCC (83.3%) and NSCLC (62.5%) were older than 60 years. Although this difference was not statistically significant, it aligns with the known epidemiological pattern that lung cancer predominantly affects older populations. Similar findings were observed in the international study by Piro R, where the mean age was 66.7 years[23]. Likewise, Goyal N reported a mean age of 59.9 years in an Indian population, consistent with our study findings[24]. Minor variations across studies may be attributed to sociodemographic differences, tobacco exposure patterns, and environmental risk factors.

Males constituted the majority (76.7%) of lung cancer cases in our study. Both SCC and NSCLC were more prevalent in males, although the difference was statistically insignificant. This finding is consistent with other Indian studies, though the study by Natasha Mittal et al. reported a comparatively higher proportion of female patients (46%)[25]. Nevertheless, most studies consistently demonstrate a male predominance, likely due to higher smoking prevalence among men.

Most patients presented within 1–3 months of symptom onset, reflecting a relatively short interval between symptom development and seeking medical care. Cough was the most common symptom (83.3%), followed by hemoptysis (53.3%), dyspnea (36.6%), and weight loss (53.3%), with similar proportions observed across SCC and NSCLC. These findings mirror earlier studies where cough was the leading symptom, as reported by Sujith B et al. (68.42%) and Goyal N (80%)[24,26]. Likewise, Mohan A et al. documented cough (81.3%) and weight loss (58.1%) as frequent symptoms in NSCLC[27]. Hemoptysis and dyspnea were also commonly seen, consistent with the classic symptomatology described in the literature[28].

History of tuberculosis was noted in 20% of NSCLC patients, with no SCC patients reporting past TB. Although not statistically significant, this proportion is higher than the 7.3% reported internationally by Nasititi et al.[29], likely reflecting India's higher TB burden. Other Indian studies also demonstrated higher TB prevalence among lung cancer patients, such as Niranjan M et al. (16%)[31].

Comorbidities were present in 63.4% of patients, with hypertension (16.6%) and cardiovascular disease (16.6%) being most common. Similar trends were reported by Tammemagi et al., where a majority of lung cancer patients had multiple comorbidities, affecting overall prognosis and treatment tolerance[31].

Smoking emerged as a major risk factor in this study, with 73.3% of patients having smoked. NSCLC patients (75%) had higher smoking rates than SCC patients (66.6%), although the association was not statistically significant. The majority (43.3%) had 20–40 pack years, indicating long-standing tobacco exposure. These observations reinforce the well-established role of smoking in lung cancer pathogenesis, with risk increasing proportionately with duration and intensity of exposure[32].

Alcohol use was reported by 23.3% of patients, with slightly higher rates among SCC cases. However, the association was not significant. Interestingly, some studies such as that by Ferhinger G et al. found an inverse association between alcohol consumption and lung cancer, although evidence remains inconsistent and confounded by smoking patterns[33].

Only one patient (3.3%) used smokeless tobacco, consistent with literature suggesting limited or inconsistent association between smokeless tobacco and lung cancer[34].

Chest X-ray findings revealed a predominantly right-sided mass (66.6%), most commonly in the right upper zone (26.6%). Similar trends were reported by Kaushik et al., where 73.08% of lung cancers were right-sided[35]. SCC cases frequently involved the right lower zone, while NSCLC cases commonly affected the right upper zone.

CECT thorax findings showed that the most common locations were the right lower lobe (20%), left upper lobe (16.6%), and right upper lobe (16.6%). SCC cases most frequently affected the right lower lobe. Tumor size ranged from 1.8 × 2.0 cm to 12 × 13 cm, with a mean size of 5.02 × 4.75 cm. These findings are comparable to the study by Gharraf et al., where the right upper lobe was the most common site and tumor size ranged widely among histological variants[36]. Ciofiac et al. also observed that SCC and SCLC were more centrally located, while adenocarcinoma tended to be peripheral[37].

Mediastinal lymph node involvement was common, with station 7 (23.3%) and 10R (20%) being the most frequently involved. Lymph node sizes averaged 2.55 × 2.11 cm. These findings are consistent with Platt et al., who also reported station 7 and 4R as commonly affected in NSCLC[38].

The most commonly sampled lymph node stations on EBUS were station 7 (23.3%) and 10R (20%). Similar patterns were observed in the study by Piro R et al., where stations 7 and 4R were most frequently sampled[23]. Other studies showed different sampling frequencies depending on patient selection, as seen in the study by Wi S et al., where station 11R was most common[39].

Most patients had a single node sampled (63.3%), aligning with the study by Wang H et al., where single-node sampling predominated (83.4%)[39].

Histopathology revealed NSCLC in 80% and SCC in 20%, with squamous cell carcinoma (23.3%) being the most common NSCLC subtype in our cohort. This differs from Verma et al., who found adenocarcinoma to be the predominant NSCLC subtype (32%)[40]. Variations may be due to regional differences in tobacco exposure and environmental factors.

Most patients had advanced disease at diagnosis, with stage III B (33.3%) and stage III A (30%) being the most common stages. Half of the SCC patients were stage IV A, indicating more extensive disease. These findings highlight the late presentation common in lung cancer. Navani N et al. also reported stage III A as the most frequent stage in their trial[41], although fewer patients had stage IV disease compared to our study.

EBUS-TBNA was generally safe, with minor complications observed in 16.6% of patients. Bleeding (13.3%) and transient desaturation (3.3%) were the only intra-procedural issues, while 13.3% developed mild post-procedure hemoptysis. No major complications occurred. These rates are comparable to previous studies reporting low complication rates for bronchoscopy and EBUS procedures[42-46].

EBUS-TBNA demonstrated a high diagnostic yield of 84.2%, markedly superior to conventional bronchoscopy (21.1%). EBUS yield remained high in both new (83.3%) and previously evaluated cases (87.5%). Suction marginally improved yield (85.7%). Diagnostic yield for malignancy was 78.9%, and EBUS-based staging was successful in all patients (100%).

Previous studies report variable EBUS yields depending on disease location and operator expertise. Tscheikuna et al. reported a lower yield of 51.6% in peripheral lesions[47], while Gerard A et al. reported an 80% yield, similar to our findings[48].

The sensitivity and specificity of EBUS-TBNA for diagnosing malignancy were 88.8% and 100%, respectively, with a PPV of 100% and NPV of 33.3%. These metrics closely resemble those reported by Verma et al., who recorded a sensitivity of 91.4% and specificity of 100%[41]. The lower NPV in our study is likely due to small sample size and the predominance of malignant pathology.

CONCLUSION

Linear EBUS-TBNA demonstrated high diagnostic accuracy and safety in evaluating centrally located lung tumors and mediastinal lymphadenopathy. In this study, EBUS-TBNA achieved a diagnostic yield of 84.2%, significantly outperforming conventional bronchoscopy, particularly in cases without visible endobronchial lesions. The procedure reliably identified malignant pathology with a sensitivity of 88.8%, specificity of 100%, and positive predictive value of 100%, underscoring its value as a first-line diagnostic tool. Most patients presented with advanced-stage disease, highlighting the importance of early detection and comprehensive mediastinal assessment. Lymph

node stations 7 and 10R were most frequently involved radiologically and were similarly the most commonly sampled on EBUS. Complication rates were low and limited to minor bleeding and transient desaturation, with no major adverse events. Overall, linear EBUS-TBNA proved to be a minimally invasive, effective, and safe modality for simultaneous diagnosis and staging, supporting its recommended role in current lung cancer evaluation protocols.

Declarations
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