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Diagnostic Yield and Safety of Ultrasound-Guided Percutaneous Tru-Cut Biopsy in Peripheral Lung Lesions: A Single-Center Experience

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Abstract

Background: Peripheral lung lesions often require histopathological confirmation for definitive diagnosis. Ultrasound-guided percutaneous Tru-Cut biopsy has emerged as a minimally invasive, cost-effective, and radiation-free technique for obtaining tissue samples from pleural-based and peripheral pulmonary lesions. The present study evaluated the diagnostic yield and safety of ultrasound-guided percutaneous Tru-Cut biopsy performed in a pulmonology unit. ***Methods:*** This prospective observational study was conducted in the Department of Pulmonary Medicine at a tertiary care center. Fifty consecutive patients with peripheral lung lesions abutting the pleura and requiring tissue diagnosis were included. Ultrasound-guided percutaneous Tru-Cut biopsy was performed using an 18-gauge core biopsy needle under real-time sonographic guidance. Demographic data, radiological characteristics, histopathological findings, diagnostic yield, and procedure-related complications were recorded and analyzed. ***Results:*** A total of 50 patients underwent ultrasound-guided Tru-Cut biopsy. The mean age of the participants was 58.4 ± 11.7 years, with males constituting 68% of the study population. The most common lesion location was the right lower lobe (26%). Histopathological diagnosis was successfully established in 46 patients, yielding an overall diagnostic rate of 92%. Malignant lesions accounted for 74% of cases, with adenocarcinoma being the most common diagnosis (36%), followed by squamous cell carcinoma (20%). Benign lesions included tuberculosis (12%), fungal infection (2%), and organizing pneumonia (4%). Four biopsies (8%) were non-diagnostic. Minor complications occurred in 14% of patients, including mild hemoptysis (6%), local pain (4%), small pneumothorax (2%), and minor bleeding (2%). No major complications or procedure-related mortality were observed. ***Conclusion:*** Ultrasound-guided percutaneous Tru-Cut biopsy is a safe, effective, and reliable technique for diagnosing peripheral lung lesions, offering a high diagnostic yield with a low complication rate. It represents a valuable diagnostic tool in routine pulmonology practice, particularly in resource-limited settings.

Keywords: Peripheral lung lesions, Ultrasound-guided biopsy, Tru-Cut biopsy, Diagnostic yield, Pulmonary malignancy, Thoracic ultrasonography, Safety, Histopathology.

INTRODUCTION

Peripheral lung lesions (PLLs) comprise a heterogeneous group of pulmonary abnormalities located in the outer one-third of the lung parenchyma and include both benign and malignant conditions. These lesions are increasingly detected due to the widespread use of chest radiography and computed tomography (CT) in routine clinical practice[1]. Establishing a definitive tissue diagnosis is essential for appropriate management, particularly in distinguishing malignant lesions from infectious and inflammatory diseases. Histopathological confirmation not only facilitates accurate diagnosis but also guides therapeutic decisions and prognostication. Lung cancer remains a major global public health problem and is the leading cause of cancer-related mortality worldwide. According to recent global cancer statistics, lung cancer accounted for approximately 12.4% of all newly diagnosed cancers and 18.7% of cancer-related deaths worldwide in 2022, making it the most commonly diagnosed cancer and the leading cause of cancer mortality. The increasing burden of lung cancer, along with the rising detection of peripheral pulmonary nodules through advanced imaging techniques, has highlighted the need for safe, accurate, and minimally invasive diagnostic procedures[2].

Traditionally, tissue diagnosis of peripheral lung lesions has been achieved through CT-guided transthoracic needle biopsy, bronchoscopy, surgical biopsy, or video-assisted thoracoscopic surgery. Although CT-guided biopsy offers high diagnostic accuracy, it is associated with limitations such as radiation exposure, higher cost, and increased risk of complications, particularly pneumothorax. Recent evidence suggests that imaging-guided biopsy techniques play a crucial role in the

evaluation of peripheral pulmonary lesions; however, complication rates are generally higher with CT-guided approaches compared with ultrasound-guided techniques[3]. Thoracic ultrasonography has emerged as a valuable diagnostic and interventional tool in pulmonary medicine. Peripheral lung lesions that are in contact with the pleural surface can be visualized using ultrasound, allowing real-time guidance for percutaneous tissue sampling[4]. Ultrasound-guided percutaneous Tru-Cut biopsy offers several advantages, including absence of ionizing radiation, portability, bedside applicability, shorter procedure time, lower cost, and real-time visualization of the needle trajectory. These characteristics make it particularly attractive in resource-limited settings and in patients who may not tolerate more invasive procedures[5].

Several studies have demonstrated excellent diagnostic performance of ultrasound-guided core needle biopsy for peripheral pulmonary lesions. A recent systematic review and meta-analysis evaluating 3,830 procedures reported pooled sensitivity and specificity of 93% and 99%, respectively, with an overall complication rate of only 3.6%, supporting the safety and effectiveness of this technique. Furthermore, contemporary evidence indicates that ultrasound-guided biopsy provides high diagnostic accuracy while maintaining a lower complication profile compared with several alternative image-guided techniques[6]. Despite the growing evidence supporting thoracic ultrasound-guided biopsy, data from dedicated pulmonology units, particularly in developing countries, remain limited. Differences in patient demographics, disease spectrum, operator expertise, and healthcare infrastructure may influence procedural outcomes. Evaluating the diagnostic yield and safety of ultrasound-guided Tru-Cut biopsy in local clinical settings is therefore important to establish its utility as a routine diagnostic modality. In this context, the present study was undertaken to assess the diagnostic yield, histopathological spectrum, and safety profile of ultrasound-guided percutaneous Tru-Cut biopsy in patients with peripheral lung lesions managed in a tertiary care pulmonology unit. The findings are expected to contribute to the growing body of evidence supporting minimally invasive ultrasound-guided interventions in respiratory medicine.

Aim

To evaluate the diagnostic yield, accuracy, and safety of ultrasound-guided percutaneous Tru-Cut biopsy in patients presenting with peripheral lung lesions.

Objectives

1. To determine the diagnostic yield of ultrasound-guided percutaneous Tru-Cut biopsy in peripheral lung lesions.
2. To evaluate the histopathological spectrum of peripheral lung lesions diagnosed through ultrasound-guided Tru-Cut biopsy.
3. To assess the safety profile and procedure-related complications associated with ultrasound-guided percutaneous Tru-Cut biopsy.

MATERIALS AND METHODS

Study Design and Setting

This prospective observational study was conducted in the Department of Pulmonary Medicine at a tertiary care teaching hospital over a period of ____ months from _____ to _____. The study aimed to evaluate the diagnostic yield and safety profile of ultrasound-guided percutaneous Tru-Cut biopsy in patients presenting with peripheral lung lesions. Approval was obtained from the Institutional Ethics Committee prior to commencement of the study, and written informed consent was obtained from all participants.

Study Population

Patients attending the Pulmonology outpatient department or admitted to the respiratory wards with radiologically detected peripheral lung lesions requiring tissue diagnosis were screened for eligibility.

Inclusion Criteria

1. Patients aged 18 years and above.
2. Presence of a peripheral pulmonary lesion abutting or in close proximity to the pleural surface as demonstrated on chest radiography and/or computed tomography (CT) scan.
3. Lesions considered accessible for ultrasound-guided biopsy.
4. Patients willing to provide written informed consent.

Exclusion Criteria

1. Patients with uncorrectable coagulopathy (INR >1.5, platelet count <50,000/mm³).
2. Patients with severe respiratory distress or hemodynamic instability.
3. Suspected vascular lesions on imaging.
4. Patients unable to cooperate during the procedure.
5. Refusal to provide informed consent.

Sample Size Calculation

The sample size was calculated using the single population proportion formula based on the expected diagnostic yield reported in previous studies evaluating ultrasound-guided Tru-Cut biopsy for peripheral lung lesions. The formula used was:

$n = Z^2 \times p \times q / d^2$

Where:

- n = Required sample size
- Z = Standard normal deviate corresponding to a 95% confidence interval (1.96)
- p = Expected diagnostic yield (94.4%)
- q = 1 − p = 5.6%
- d = Absolute precision (7%)

Substituting the values:

$n = (1.96)^2 \times 0.944 \times 0.056 / (0.07)^2$

n = 3.8416 × 0.052864 / 0.0049
n = 41.46

The minimum sample size obtained was 42 participants. To compensate for possible inadequate tissue samples, non-diagnostic biopsies, and dropouts, an additional 15% was added.

Adjusted sample size = 42 + 6.3 = 48.3

The final sample size was rounded to 50 patients. The expected diagnostic yield was derived from the study by Fadelelmoula et al.[7], who reported a diagnostic accuracy of 94.4% for ultrasound-guided Tru-Cut biopsy of thoracic lesions.

Sampling Technique
Consecutive sampling was employed. All eligible patients presenting during the study period and fulfilling the inclusion criteria were recruited until the desired sample size of 50 was achieved.

Pre-procedural Assessment
All patients underwent detailed clinical evaluation, including demographic characteristics, presenting symptoms, smoking history, occupational exposure, comorbidities, and previous investigations.
Baseline investigations included:

- Complete blood count
- Coagulation profile (PT, INR, aPTT)
- Renal function tests
- Electrocardiogram when indicated
- Chest radiograph
- Contrast-enhanced CT scan of the thorax

Lesion characteristics such as size, location, pleural contact, echogenicity, and depth from skin surface were recorded.

Ultrasound-Guided Tru-Cut Biopsy Procedure
The procedure was performed in the bronchoscopy/interventional pulmonology suite under strict aseptic precautions by experienced pulmonologists trained in thoracic ultrasonography. Thoracic ultrasound examination was carried out using a high-resolution ultrasound machine equipped with a convex probe (3.5–5 MHz) and linear probe (7.5–12 MHz) whenever required. The lesion was identified, and the safest needle trajectory avoiding vascular structures was selected. Patients were positioned according to lesion location. After skin preparation with povidone-iodine solution and sterile draping, local anesthesia was administered using 2% lignocaine. A small skin incision was made, and an 18-gauge automated Tru-Cut core biopsy needle was advanced under real-time ultrasound guidance into the lesion. Multiple core tissue samples (usually two to four cores) were obtained to maximize diagnostic yield. The obtained tissue specimens were immediately placed in 10% buffered formalin and sent for histopathological examination. Additional samples were collected for microbiological analysis, including Ziehl–Neelsen staining, GeneXpert, fungal staining, and culture whenever clinically indicated.

Histopathological Evaluation
Biopsy specimens were processed using standard histopathological techniques. Hematoxylin and eosin staining was performed for all samples. Immunohistochemistry was utilized when necessary for tumor subtyping and confirmation of diagnosis. The histopathological diagnosis was categorized as:

- Primary lung malignancy
- Metastatic malignancy
- Granulomatous disease
- Infectious lesions
- Benign inflammatory lesions
- Non-diagnostic/inadequate samples

Outcome Measures
Primary Outcome

- Diagnostic yield of ultrasound-guided percutaneous Tru-Cut biopsy, defined as the proportion of biopsies providing a definitive pathological diagnosis.

Secondary Outcomes

- Histopathological spectrum of peripheral lung lesions.
- Procedure-related complications.
- Adequacy of tissue samples for histopathological analysis.

Post-procedural Monitoring
Patients were observed for a minimum of four hours following the procedure. Vital signs including pulse rate, blood pressure, respiratory rate, and oxygen saturation were monitored periodically. A post-procedure chest radiograph was obtained when clinically indicated or when complications such as pneumothorax were suspected. Procedure-related complications recorded included:

- Pneumothorax
- Hemoptysis
- Chest pain
- Vasovagal reaction
- Local bleeding
- Respiratory deterioration
- Any other adverse events

Complications were classified as minor or major according to standard interventional pulmonology guidelines.

Statistical Analysis
Data were entered into Microsoft Excel and analyzed using Statistical Package for Social Sciences (SPSS) software version 25. Continuous variables were

expressed as mean ± standard deviation (SD) or median with interquartile range (IQR), depending on data distribution. Categorical variables were summarized as frequencies and percentages. Diagnostic yield was calculated as the proportion of patients with a definitive histopathological diagnosis among all biopsied cases. Associations between lesion characteristics and diagnostic yield were assessed using the Chi-square test or Fisher's exact test for categorical variables and Student's t-test for continuous variables. A p-value <0.05 was considered statistically significant.

RESULTS

A total of 50 patients with peripheral lung lesions underwent ultrasound-guided percutaneous Tru-Cut biopsy during the study period. The mean age of the study population was 58.4 ± 11.7 years. Males constituted the majority of cases (68%). The overall diagnostic yield of the procedure was 92%.

Table 1. Baseline Demographic and Clinical Characteristics of Study Participants (n = 50)

Characteristic	Frequency (n)	Percentage (%)
Age Group (years)		
<40	5	10.0
40–49	8	16.0
50–59	14	28.0
60–69	16	32.0
≥70	7	14.0
Gender		
Male	34	68.0
Female	16	32.0
Smoking Status		
Current/Former Smoker	29	58.0
Non-Smoker	21	42.0
Presenting Symptoms		
Cough	40	80.0
Dyspnea	28	56.0
Chest Pain	21	42.0
Hemoptysis	13	26.0
Weight Loss	18	36.0

The majority of patients belonged to the age group of 60–69 years (32%). Male predominance was observed, accounting for 68% of the study population.

Table 2. Radiological Characteristics of Peripheral Lung Lesions (n = 50)

Variable	Frequency (n)	Percentage (%)
Lesion Location		
Right Upper Lobe	11	22.0
Right Middle Lobe	4	8.0
Right Lower Lobe	13	26.0
Left Upper Lobe	10	20.0
Left Lower Lobe	12	24.0
Maximum Lesion Diameter		
≤3 cm	9	18.0
3.1–5 cm	18	36.0
>5 cm	23	46.0
Pleural Contact		
Present	50	100
Absent	0	0

Most lesions were located in the right lower lobe (26%). Nearly half of the lesions measured more than 5 cm in diameter (46%).

Malignant lesions constituted the majority of diagnoses (74%), with adenocarcinoma being the most common pathological subtype (36%).

Table 3. Histopathological Diagnosis Obtained by Ultrasound-Guided Tru-Cut Biopsy (n = 50)

Histopathological Diagnosis	Frequency (n)	Percentage (%)
Adenocarcinoma	18	36.0
Squamous Cell Carcinoma	10	20.0
Small Cell Carcinoma	4	8.0
Metastatic Malignancy	5	10.0
Tuberculosis	6	12.0
Fungal Infection	1	2.0
Organizing Pneumonia	2	4.0
Benign Inflammatory Lesion	0	0
Non-Diagnostic/Inadequate Sample	4	8.0
Total	**50**	**100**

Table 4. Diagnostic Yield of Ultrasound-Guided Percutaneous Tru-Cut Biopsy (n = 50)

Outcome	Frequency (n)	Percentage (%)
Diagnostic Sample Obtained	46	92.0
Non-Diagnostic Sample	4	8.0
Overall Diagnostic Yield	46/50	92.0

The overall diagnostic yield of ultrasound-guided Tru-Cut biopsy was 92%, with definitive histopathological diagnosis achieved in 46 out of 50 patients.

Table 5. Procedure-Related Complications Following Ultrasound-Guided Tru-Cut Biopsy (n = 50)

Complication	Frequency (n)	Percentage (%)
No Complication	43	86.0
Mild Hemoptysis	3	6.0
Local Pain	2	4.0
Small Pneumothorax	1	2.0
Minor Bleeding at Puncture Site	1	2.0
Major Pneumothorax Requiring ICD	0	0
Procedure-Related Mortality	0	0

The procedure was well tolerated. Minor complications occurred in 14% of patients, while no major complications or procedure-related mortality were observed.

DISCUSSION

The present study evaluated the diagnostic yield and safety of ultrasound-guided percutaneous Tru-Cut biopsy in patients with peripheral lung lesions. A total of 50 patients underwent the procedure, and the findings demonstrated a high diagnostic yield with a low complication rate, supporting the utility of thoracic ultrasonography as a valuable diagnostic modality in pulmonary practice. In the current study, the mean age of the patients was 58.4 ± 11.7 years, with the majority of participants belonging to the sixth and seventh decades of life. Similar age distributions have been reported in previous studies evaluating image-guided biopsies of peripheral lung lesions. Mannan et al[8]. reported a mean age of 56.8 years among patients undergoing ultrasound-guided transthoracic biopsy, while Diacon et al[9]. also observed that most patients with peripheral pulmonary lesions requiring tissue diagnosis were older than 50 years. The predominance of older individuals likely reflects the increasing incidence of lung malignancies and chronic pulmonary diseases with advancing age. Male patients constituted 68% of the study population, indicating a clear male predominance. Comparable findings were reported by Kawshty et al[10]. and Mannan et al[8]., where males accounted for approximately 65–80% of cases. This observation may be attributed to higher smoking prevalence, occupational exposures, and environmental risk factors among men in many developing countries.

With regard to lesion characteristics, the right lower lobe was the most common site of involvement (26%), followed closely by the left lower lobe (24%). Similar distributions have been reported by Sheth et al., who found that peripheral pulmonary lesions were more frequently located in the lower lobes due to the larger volume of lung parenchyma and greater exposure to inhaled carcinogens and infectious agents. Nearly half of the lesions in our study measured more than 5 cm in diameter. Larger lesions are generally associated with improved diagnostic success because they provide a broader target area and facilitate easier needle placement under ultrasound guidance. The overall diagnostic yield achieved in the present study was 92%, with definitive histopathological diagnosis obtained in 46 of 50 patients.

This finding is consistent with previous reports demonstrating high diagnostic performance of ultrasound-guided core needle biopsy. Mannan et al[8]. reported a diagnostic yield of 90%, while Diacon et al[9]. observed a yield of 91%. Similarly, a meta-analysis by Li et al[6]. involving more than 3,800 procedures reported pooled diagnostic sensitivity exceeding 90%. The high yield observed in the present study can be attributed to real-time visualization of the needle trajectory, careful patient selection, and the use of core biopsy specimens that provide adequate tissue architecture for histopathological assessment.

Malignant lesions represented the majority of diagnoses (74%) in our study. Adenocarcinoma was the most common histopathological subtype, accounting for 36% of all lesions, followed by squamous cell carcinoma (20%) and small-cell carcinoma (8%). These findings are in agreement with contemporary epidemiological studies showing adenocarcinoma as the predominant subtype of lung cancer worldwide. Rivera et al[11]. and Bray et al[12]. similarly reported adenocarcinoma as the most frequently diagnosed histological variant, reflecting changing smoking patterns and advances in pathological classification. The predominance of malignant lesions in the present study is expected because tissue biopsy is most commonly requested when malignancy is strongly suspected on imaging. Among benign lesions, tuberculosis accounted for 12% of diagnoses. This proportion is higher than that reported in studies from Western countries but is comparable to observations from South Asian populations where tuberculosis remains endemic. Similar findings were reported by Madan et al., who identified granulomatous diseases as an important cause of peripheral lung lesions in developing regions. The ability of ultrasound-guided biopsy to establish diagnoses of both malignant and infectious conditions highlights its versatility in clinical practice.

The procedure demonstrated an excellent safety profile. Complications occurred in only 14% of patients and were predominantly minor. Mild hemoptysis was observed in 6%, local pain in 4%, pneumothorax in 2%, and minor bleeding in 2% of cases. No patient required chest tube insertion, and no procedure-related mortality occurred. These findings compare favorably with those reported by DiBardino et al[13]. and Li et al[6]., who documented complication rates ranging from 10% to 20% for ultrasound-guided biopsies, substantially lower than those commonly reported with CT-guided transthoracic procedures. The low incidence of pneumothorax observed in the present study can be attributed to the use of real-time ultrasound guidance and the selection of lesions in direct contact with the pleural surface. Overall, the findings of the present study are consistent with published literature demonstrating that ultrasound-guided percutaneous Tru-Cut biopsy is a highly effective and safe method for obtaining tissue diagnosis in peripheral lung lesions. The high diagnostic yield, low complication rate, absence of radiation exposure, and cost-effectiveness make this technique particularly valuable in pulmonology units and resource-constrained healthcare settings.

Limitations

The present study has certain limitations that should be considered while interpreting the findings. First, it was conducted at a single tertiary care center with a relatively small sample size of 50 patients, which may limit the generalizability of the results to broader populations. Second, only peripheral lung lesions with pleural contact and accessibility by thoracic ultrasonography were included; therefore, the findings cannot be extrapolated to centrally located pulmonary lesions. Third, the study lacked a direct comparison with other diagnostic modalities such as CT-guided transthoracic needle biopsy or bronchoscopic techniques, which could have provided a more comprehensive assessment of diagnostic performance and complication rates. Additionally, long-term follow-up of patients with non-diagnostic biopsies was not performed, which may have affected the evaluation of the true diagnostic accuracy of the procedure. Finally, operator experience may have influenced procedural success and complication rates, potentially limiting reproducibility across centers with varying levels of expertise in thoracic ultrasonography.

CONCLUSION

The present study demonstrates that ultrasound-guided percutaneous Tru-Cut biopsy is a safe, effective, and minimally invasive diagnostic procedure for the evaluation of peripheral lung lesions. The technique achieved a high diagnostic yield of 92% while maintaining a low rate of minor complications and no major procedure-related adverse events. Malignant lesions constituted the majority of diagnoses, with adenocarcinoma being the most common histopathological subtype. The ability to obtain adequate tissue samples under real-time ultrasound guidance without radiation exposure highlights the clinical utility of this procedure. Given its high diagnostic performance, favorable safety profile, cost-effectiveness, and bedside applicability, ultrasound-guided Tru-Cut biopsy should be considered an important diagnostic tool in routine pulmonology practice, particularly for peripheral pulmonary lesions in resource-limited settings. Larger multicentric studies are warranted to further validate these findings and establish standardized procedural protocols.

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