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Diagnostic Utility Of Flexible Bronchoscopy In Lung Lesions: A Prospective Study

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Abstract:
Background: *Flexible bronchoscopy is a minimally invasive technique for diagnosing lung lesions. This study evaluated the diagnostic yield of bronchial washings, brushings, bronchoalveolar lavage (BAL), and transbronchial biopsy (TBB) in 100 patients over two years.*
Objective*: To compare the diagnostic efficacy of bronchial washings, brushings, BAL, and TBB in lung lesion evaluation at Maharajah's Institute of Medical Sciences over a two-year period.*
Methods: *A prospective observational study was conducted over two years at Maharajah's Institute of Medical Sciences. A total of 100 patients with radiologically detected lung lesions underwent bronchoscopy. Samples were analyzed for cytological, microbiological, and histopathological findings.*
Results: *TBB had the highest diagnostic yield (78%), particularly for malignancies. BAL showed superior sensitivity (85%) in detecting infectious etiologies such as tuberculosis and fungal pneumonia. Brushings and washings were effective (60–70%) in diagnosing centrally located tumors. Combining multiple techniques increased overall diagnostic accuracy.*
Conclusion: *Bronchoscopy remains an essential, minimally invasive tool in diagnosing lung lesions. The combination of BAL, brushings, and TBB improves diagnostic sensitivity, particularly for malignant and infectious pathologies.*
Keywords: *Bronchoscopy, Transbronchial Biopsy, BAL, Cytology, Pulmonary Malignancy*

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I. Introduction

Lung lesions detected via imaging often require tissue or cellular diagnosis to differentiate between malignancies, infections, and interstitial lung diseases. Flexible bronchoscopy allows for direct visualization and sample collection, with techniques including:

•Bronchial Brushings – Cytological analysis of exfoliated tumor cells.
•Bronchial Washings – Fluid analysis for atypical cells and infectious agents.
•Bronchoalveolar Lavage (BAL) – Essential for diagnosing diffuse lung diseases and infections.
•Transbronchial Biopsy (TBB) – Provides histopathological confirmation, especially for malignancies.

Multiple studies have demonstrated varied diagnostic yields, ranging from 40% to 85%, depending on the technique and underlying pathology

The widespread adoption of high-resolution computed tomography (HRCT) and contemporary lung cancer screening programs has led to a significant increase in the incidental and targeted detection of pulmonary lesions. However, the radiological identification of these lesions often presents a complex clinical dilemma. Because imaging alone is rarely definitive, obtaining a precise tissue or cellular diagnosis is paramount to accurately differentiate between primary or metastatic malignancies, atypical infections, and a spectrum of interstitial lung diseases (ILDs). Prompt and accurate pathological characterization is the cornerstone of formulating effective, patient-specific therapeutic strategies.

In this diagnostic algorithm, flexible bronchoscopy remains a vital, minimally invasive modality. It provides clinicians with the dual advantage of direct endobronchial visualization and the ability to perform targeted sample collection through a variety of complementary techniques. By tailoring the sampling approach to the patient's specific radiological presentation, pulmonologists can maximize diagnostic accuracy. The primary bronchoscopic sampling modalities include:

Bronchial Brushings: This technique involves the mechanical exfoliation of the bronchial mucosa or tumor surface. It is highly effective for cytological analysis, particularly for visible endobronchial lesions where surface tumor cells can be readily captured.

Bronchial Washings: By instilling and aspirating sterile saline in the proximal airways, this fluid analysis collects loosely adherent atypical cells and infectious agents. It serves as a valuable adjunct to brushing, often capturing diagnostic material that sheds proximally from distal lesions.

Bronchoalveolar Lavage (BAL): BAL extends sampling to the distal airways and alveolar compartments. The cytological and microbiological profiles obtained from BAL fluid are essential for diagnosing diffuse parenchymal lung diseases, identifying opportunistic pulmonary infections, and evaluating alveolar hemorrhage syndromes.

Transbronchial Biopsy (TBB): While cytological techniques evaluate isolated cells, TBB utilizes forceps to acquire intact lung tissue. This provides critical histopathological architecture, which is often required for the definitive subtyping of malignancies, as well as the diagnosis of granulomatous conditions and structural lung diseases.

Despite the standard integration of these techniques into clinical practice, the literature indicates a highly variable diagnostic yield, broadly ranging from 40% to 85%. This significant variance is multifactorial, heavily influenced by the specific technique utilized, the underlying histopathology of the lesion, and anatomical factors such as lesion size and location (central versus peripheral). Furthermore, the combined use of these modalities may offer synergistic diagnostic value, though the optimal algorithm remains a subject of ongoing clinical investigation.

II. Material And Methods

Study Design & Population

Study Type: Prospective observational study.

Study Duration: December 2023 to December 2025

Sample Size: 100 patients with radiologically confirmed lung lesions.

Study location: Department of Respiratory Medicine, Maharajah's institute of medical sciences, Nellimarla, Andhra Pradesh, India

Inclusion Criteria:
1. Patients with lung nodules, masses, or infiltrates.
2. Suspected cases of tuberculosis, fungal infections, or interstitial lung diseases.

Exclusion Criteria:
1. Patients with severe bleeding risk.
2. Hemodynamically unstable patients.
3. Patients unwilling to provide informed consent.

Procedure

Informed written consent was obtained from all patients or their legal guardians prior to the procedure. Thorough pre-procedural evaluations, including complete blood picture, coagulation profile (PT/INR), renal and liver function tests, viral markers, and an electrocardiogram (ECG), were performed for all candidates. Patients were kept strictly nil per os (NPO) for at least 6 hours prior to the procedure.

Flexible bronchoscopy was performed in a dedicated bronchoscopy suite using a standard video bronchoscope. The procedure was primarily conducted under local anesthesia. The oropharynx was anesthetized using a 10% lignocaine spray, and 2% lignocaine was instilled in aliquots of 2 ml through the working channel of the bronchoscope to suppress the cough reflex at the vocal cords and tracheobronchial tree. Intravenous midazolam (1–2 mg) was administered for conscious sedation when clinically indicated and tolerated by the patient. Throughout the procedure, patients were continuously monitored for oxygen saturation (SpO2), heart rate, and blood pressure.

Upon visualization of the tracheobronchial tree, targeted sampling was performed based on the radiological location and bronchoscopic appearance of the lesion:

Bronchial Washings: 20–30 ml of sterile normal saline was instilled into the target segmental or subsegmental bronchus and aspirated into a sterile trap for fluid analysis.

Bronchial Brushings: A sterile cytology brush was passed through the working channel and rubbed directly against visible endobronchial lesions. For peripheral lesions, brushing was performed under fluoroscopic guidance where applicable.

Bronchoalveolar Lavage (BAL): The bronchoscope was wedged into the appropriate subsegmental bronchus, and 100-150 ml of sterile normal saline (in aliquots of 30-50 ml) was instilled and gently aspirated.

Transbronchial Biopsy (TBB): Standard cupped biopsy forceps were used to obtain 3 to 5 parenchymal tissue samples to provide histopathological confirmation.

All collected samples were immediately fixed in 10% formalin (for histopathology) or transported in sterile containers for comprehensive cytological and microbiological evaluation (including Acid-Fast Bacilli smear, GeneXpert MTB/RIF, routine cultures, and fungal cultures).

Statistical Analysis

Data were systematically recorded in a Microsoft Excel spreadsheet and analyzed using SPSS Statistics software (Version 26.0, IBM Corp.). Continuous variables, such as patient age, were expressed as mean ± standard deviation (SD). Categorical variables, including the diagnostic yield of each bronchoscopic modality, were expressed as frequencies and percentages. The overall diagnostic yield was calculated as the percentage of cases where a specific technique successfully provided a definitive diagnosis relative to the total number of cases. Chi-square tests were utilized to compare the diagnostic sensitivities between different sampling techniques. A p-value of <0.05 was considered statistically significant.

Bronchoscopic Sampling Methods

Technique	Diagnostic Yield (%)	Number of Positive Cases (n = 100)	Best for Diagnosing
Bronchial Washings	60%	60	Central lung tumors, infections
Bronchial Brushings	65%	65	Central lung tumors, infections
BAL	85%	85	Tuberculosis, fungal pneumonia, Interstitial lung disease
TBB	78%	78	Adenocarcinoma, sarcoidosis, granulomatous infections

III. Results

Demographic and Clinical Characteristics Out of the 100 patients enrolled in the study, there was a male predominance with 68 males (68%) and 32 females (32%). The mean age of the study population was 54.2 ± 12.5 years, ranging from 28 to 76 years. The most common presenting symptoms were chronic cough, hemoptysis, and dyspnea. All 100 patients successfully underwent the planned bronchoscopic procedures, and the samples were sent for respective analyses. The procedures were generally well-tolerated, with only minor complications such as transient hypoxemia and minimal self-limiting hemoptysis noted in a small fraction of patients; no major adverse events such as severe hemorrhage or pneumothorax requiring intervention occurred.

Overall Diagnostic Yield of Bronchoscopic Techniques The comparative analysis of the four bronchoscopic modalities revealed significant variations in diagnostic efficacy based on the technique utilized. Transbronchial Biopsy (TBB) provided a definitive diagnosis in 78 out of 100 cases, resulting in an overall diagnostic yield of 78%. Bronchoalveolar Lavage (BAL) demonstrated the highest overall yield across the entire cohort, successfully identifying the underlying pathology in 85% of cases. Bronchial brushings and washings yielded positive diagnostic results in 65% and 60% of the patients, respectively.

Pathology-Specific Diagnostic Efficacy

When stratifying the diagnostic yield by the underlying pathology, distinct advantages for specific modalities emerged, underscoring the necessity of a combined approach:

Malignancies (Lung Cancer): For the diagnosis of suspected pulmonary malignancies, TBB proved to be the most definitive modality, achieving a diagnostic yield of 78%. It was particularly efficacious for peripheral lung lesions. Bronchial brushings and washings showed moderate to high diagnostic utility for malignancies, yielding 65% and 60% respectively, making them highly effective for visually accessible, centrally located tumors. BAL had the lowest yield for malignancies at 30%.

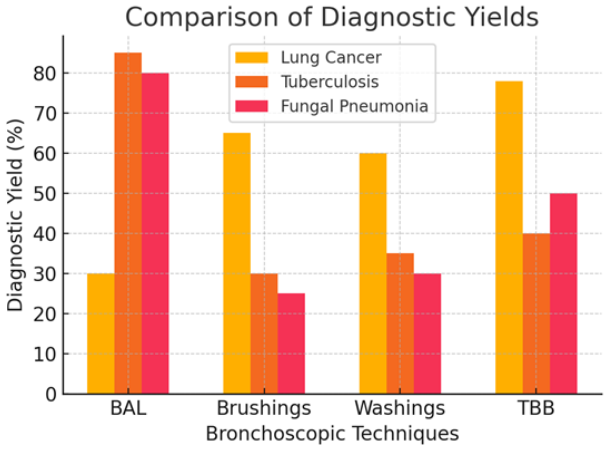
Infectious Diseases (Tuberculosis & Fungal Pneumonia): In cases of suspected pulmonary tuberculosis, BAL demonstrated superior sensitivity, providing a definitive diagnosis in 85% of cases. TBB was diagnostic in 40% of these cases , while washings and brushings provided lower yields of 35% and 30%, respectively. Similarly, BAL was the most effective diagnostic tool for fungal pneumonia, successfully identifying the pathogen in 80% of cases. TBB provided a diagnosis in 50% of fungal cases , whereas washings (30%) and brushings (25%) were less effective.

Interstitial Lung Disease (ILD): For the evaluation of diffuse parenchymal infiltrates and ILDs, BAL again showed high diagnostic value with a 75% yield. TBB provided supportive histopathological evidence in 60% of ILD cases , whereas washings (25%) and brushings (20%) had limited utility.

Primary Findings
•TBB showed a 78% overall diagnostic yield and was most effective for malignancies and was most useful in peripheral lung lesions.
•BAL had the highest sensitivity (85 cases) for infectious diseases, particularly tuberculosis and fungal pneumonia.
•Brushings and washings were more effective (60–70 cases) in detecting centrally located tumors.

Table 1: Diagnostic Yield of Bronchoscopic Techniques

Pathology	BAL (%)	Brushings (%)	Washings (%)	TBB (%)
Lung Cancer	30%	65%	60%	78%
Tuberculosis	85%	30%	35%	40%
Fungal Pneumonia	80%	25%	30%	50%
Interstitial Lung Disease	75%	20%	25%	60%



IV. Discussion

The present prospective observational study evaluated the diagnostic utility of various flexible bronchoscopic techniques—namely bronchoalveolar lavage (BAL), bronchial brushings, bronchial washings, and transbronchial biopsy (TBB)—in patients with radiologically detected lung lesions. Our findings reaffirm that flexible bronchoscopy remains an indispensable, minimally invasive diagnostic modality, with its yield significantly influenced by both the sampling technique and the underlying pathology.

Comparison with Existing Literature

Our results are consistent with established literature demonstrating that no single bronchoscopic modality is universally superior; rather, each technique has distinct advantages depending on the clinical context.

Malignancies:

In our study, TBB showed a 78% overall diagnostic yield and was most effective for malignancies, particularly in peripheral lesions. This finding aligns with previous studies, where histopathological sampling via TBB has been shown to provide definitive diagnosis in suspected malignancies. Bilaceroglu et al. reported a high diagnostic accuracy of transbronchial biopsy in peripheral lung lesions, emphasizing its importance in obtaining tissue architecture for malignancy confirmation [4]. Similarly, Mondoni et al. highlighted that bronchoscopic techniques, especially when guided appropriately, play a crucial role in diagnosing peripheral pulmonary lesions [5].

Bronchial brushings and washings in our study showed moderate diagnostic yields (65% and 60%, respectively), particularly for centrally located tumors. This observation is supported by existing guidelines, which state that cytological techniques are especially useful for visible endobronchial lesions, where tumor cells can be easily exfoliated and sampled [1].

Infectious Diseases:

BAL demonstrated the highest diagnostic sensitivity (85%) for infectious etiologies such as tuberculosis and fungal pneumonia. This is in accordance with established evidence that BAL is highly effective in diagnosing pulmonary infections, particularly in cases where sputum analysis is inconclusive. Poletti et al. emphasized the critical role of BAL in identifying infectious and inflammatory processes within the distal airways and alveolar spaces [2]. Additionally, BAL has been shown to improve microbiological yield in tuberculosis, especially in smear-negative cases [3].

Interstitial Lung Disease (ILD):

For diffuse parenchymal lung diseases, BAL showed a high diagnostic yield (75%), with TBB providing supportive histopathological evidence in selected cases. BAL is well-recognized as an essential tool in the evaluation of ILDs, offering valuable cellular and immunological information, while TBB contributes to structural and histological assessment [2].

Combined Modalities:

An important observation in our study is that combining multiple bronchoscopic techniques significantly enhances overall diagnostic accuracy. This finding is strongly supported by recent systematic reviews and meta-analyses, which demonstrate that multimodal bronchoscopic approaches improve diagnostic yield and safety profiles compared to single-technique strategies [6]. Therefore, a combination of BAL, brushings, and biopsy should be considered standard practice in the evaluation of undiagnosed lung lesions.

Clinical Implications

Based on our findings and existing evidence, the selection of bronchoscopic techniques should be individualized according to lesion characteristics:
Central lesions: Bronchial brushings and washings are highly effective due to direct visualization.
Peripheral lesions: TBB remains the preferred modality for obtaining definitive histopathological diagnosis.
Diffuse infiltrates: BAL should be prioritized for diagnosing infections and interstitial lung diseases.
Such a tailored approach optimizes diagnostic yield while minimizing procedural risks.

Study Limitations

This study has certain limitations. Being a single-center study with a relatively small sample size (n = 100), the generalizability of the findings may be limited. Additionally, bronchoscopic diagnostic yield is operator-dependent and may vary based on expertise and availability of advanced guidance techniques such as endobronchial ultrasound (EBUS) or navigation bronchoscopy. Future multicenter studies incorporating these advanced modalities are warranted to further enhance diagnostic precision.

V. Conclusion

Flexible bronchoscopy remains a vital, high-yield, and minimally invasive diagnostic intervention for pulmonary abnormalities. This analysis validates that TBB is the optimal choice for diagnosing malignancies, BAL is most effective for isolating respiratory infections, and the combination of brushings and washings is highly reliable for central airway tumors. To achieve maximum diagnostic accuracy, employing a concurrent, multi-technique sampling strategy must be maintained as the standard protocol in pulmonological practice.

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