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ANALYSIS OF SPECTRUM OF PATHOLOGICAL LESIONS IN BRONCHIAL BRUSH, WASH, BIOPSIES IN CORRELATION WITH CLINICORADIOLOGICAL FEATURES

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ABSTRACT

Overview: Proactive and meticulous clinical impression of pulmonary irregularities is vital to develop therapeutic strategies. While Endobronchial Tissue Sampling, Bronchial Brushings, Washings serve as the primary that offer valuable supplementary insight—particularly when tissue retrieval is constrained or when cytological evaluation offers earlier results than histopathology. This investigation evaluates the diagnostic effectiveness and pathological landscape of bronchial brush, wash, and biopsy samples.

Methods: Using Simple Random Sampling, a total of 100 patients undergoing Endobronchial Tissue Sampling with suspicious pulmonary lesions were selected. Cases presenting with respiratory symptoms after general examination, radiological assessment, and pathological findings were scrutinized and information was compiled and organized for further data analysis

Results: In this study of 100 patients with suspected lung lesions, male predominance (60%) and peak incidence in the 41–60 age group were observed. Cough was the most frequent symptom. Bronchial biopsy showed the highest diagnostic concordance (96.8%), followed by brush cytology (89.5%) and wash cytology (79.4%). Diagnostic success varied by lesion location, with central lesions being most accessible. Squamous cell carcinoma was the most common malignancy in older patients. Findings affirm the complementary roles of cytology and histology in lung lesion evaluation.

Conclusion: Endobronchial Tissue Sampling remains the most robust and handy tool, but combining all modalities enhances the overall diagnostic efficiency. Correlation with radiological and clinical features improves diagnostic confidence and guides targeted management.

Keywords: Endobronchial Tissue Sampling, Bronchial Brushings, Simple Random Sampling, histopathology

INTRODUCTION

Pulmonary malignancy continues to be a major health fiasco. In 2020, there were an estimated 2.2 million new cases and 1.8 million deaths attributed to lung cancer, occupying the premier spot for cancer-related ailments and fatalities [1]. Despite entering the age of digital transformation, preemptive and accurate spotting still remains a challenge, particularly in limited settings [2] [3] [4]. Visual Bronchi Assessment (Bronchoscopy) has emerged as a cornerstone in the diagnostic algorithm for assessment of various strata of pulmonary lesions [5] [6] [7].

Among the various procedures, Bronchial diagnostic sampling methods are used to obtain cytological and histopathological specimens [8]. Each technique targets different anatomical levels—ranging from superficial

epithelial cells to deeper tissue layers—offering unique diagnostic insights.Bronchial brushing facilitates the sampling of surface-level exfoliated cells from abnormal airway lesions, whereas bronchial washings enable the retrieval of cellular material from more extensive or less accessible regions of the bronchial tree [9] [10]. Tissue sampling on the other hand performs accurate histological subtyping and detailed molecular testing [11]. The timely detection of cellular atypia or malignant changes through these bronchoscopic tools can significantly increase Disability adjusted life yearly **(DALY)** [12] and increase the patient survival outcomes. Also, as molecular and immunohistochemically analyses have increasingly become vital in the era of personalized medicine to detect disease precociously and start therapeutic rehabilitation aptly on time.

Radiological imaging techniques and bronchial diagnostic sampling methods are inseparable, much like bread and butter. Therefore, integrating clinical presentation, radiological features, and pathological findings is essential for a comprehensive diagnostic approach.

This investigation aims to find out the correlation between clinical findings, radiological features, and pathological outcomes derived from bronchial brushings, washings, and biopsies in patients undergoing bronchoscopy for suspected pulmonary malignancies. By comprehensively evaluating the diagnostic yield of each sampling technique and aligningresults with clinical and imaging data, the study aims to uncover diagnostic patterns that enhance efficiency and support meticulous and good decision making.

MATERIALS AND METHODS

The study was conducted in Saveetha Medical College, Thandalam, Chennai from March 2024 to April 2025. Written informed consent was obtained from all study participants, and ethical approval was granted by the institutional ethics committee in the usage of human volunteers. Of the 150 patients who consented to participate, (n-100) were randomly selected using the lottery method. Each participant underwent a comprehensive evaluation that included recording a detailed history and performing a clinical examination using a standardized and based on the history the specimens were collected using Endobronchial tissue sampling methods. Patients aged ≥18 years undergoing bronchoscopy with brush, wash, and/or biopsy and cases showing radiological evidence of pulmonary lesions were entry perquisites. Patients on anti-tubercular treatment or chemotherapy for >2 weeks prior to sampling, pregnant, lactating woman and children aged 0-15 years were excluded from the study.

Patients with suspected pulmonary abnormalities underwent comprehensive clinical assessment, including documentation of demographics, symptoms, and risk factors. Radiological imaging (CT/HRCT) was used to localize and characterize lesions. Based on imaging findings, bronchoscopic sampling—including bronchial brushing, washing, and biopsy—was performed to collect cytological and tissue specimens. These samples were processed using standard cytological stains (Papanicolaou, Giemsa) and histopathological techniques (H&E), with multiple samples obtained to optimize diagnostic accuracy and enable further molecular evaluation [13].

STATISTICAL ANALYSIS

Data were analyzed using SPSS version 26 . Descriptive statistics summarized patient demographics and clinical characteristics. Inferential statistics based on the descriptive statistics was applied accordingly.

OBSERVATIONS AND RESULTS

Table 1: Demographic and Clinical Profile of Patients (n=100)

Variable	**Categories**	**Frequency (n)**	**Mean** ± SD scores P value
Age (years)	18–40	20	53.03±14.81
	41–60	45	
	>60	35	
Gender	Male	60	p< 0.001*
	Female	40	
Smoking History	Smoker	48	p>0.005**
	Non-smoker	52	
Common Symptoms	Cough	86	P<0.005***
	Hemoptysis	30	
	Dyspnea	24	

Lesion Size	Malignant	52	4.2 ± 0.8
	Non Malignant	48	2.7 ± 0.9 P<0.001****
Lesion Location	- Right Upper Lobe	34	P<0.001*****
	- Left Lower Lobe	26	
	- Other Lobes	40	
	Lesion Size >3 cm	60	
	Cavitary Lesions	18	
	Hilar Lymphadenopathy	28	

*t=3.38, **t= 2.93, *** χ^2= 16.27, ****t=1.79, *****f= 13.88

Among the 100 patients studied, the majority were between 41–60 years of age (45%), with a mean age of 53.03 ± 14.81 years. Males were predominant (60%) with a statistically significant association ($p < 0.001$). While 48% had a history of smoking, no significant correlation was observed with the condition ($p > 0.005$). Cough emerged as the most common symptom (86%) and was significantly associated ($p < 0.005$), followed by hemoptysis (30%) and dyspnea (24%). Malignant lesions were larger in size (4.2 ± 0.8 cm) compared to non-malignant ones (2.7 ± 0.9 cm), with a highly significant difference ($p < 0.001$). The right upper lobe was the most frequent site of lesion (34%), also showing statistical significance ($p < 0.001$).

Table 2: Spectrum of Pathological Diagnoses

Diagnosis	**Frequency (n)**	**Mean Age (years) ± SD**	
Squamous Cell Carcinoma	25	65.2 ± 8.1	
Adenocarcinoma	15	62.5 ± 7.9	**f= 12.48**
Small Cell Carcinoma	12	64.0 ± 6.7	**p<0.001**
Tuberculosis	28	48.6 ± 10.4	
Inflammatory/Benign Lesions	20	46.3 ± 11.1	

There is a statistically significant difference in the mean age across diagnostic categories (**$f = 12.48$, $p < 0.001$**), indicating age may play a role in disease distribution. Malignancies such as **squamous cell carcinoma (65.2 ± 8.1 years)**, **adenocarcinoma (62.5 ± 7.9 years)**, and **small cell carcinoma (64.0 ± 6.7 years)** were more common in older individuals. In contrast, **tuberculosis (48.6 ± 10.4 years)** and **inflammatory/benign lesions (46.3 ± 11.1 years)** occurred in relatively younger patients, reflecting a potential age-related pattern in the underlying etiology.

Table 3: Cytology and Histopathology Correlation

Diagnosis	***Cytology Positive (n)***	***Histopathology Confirmed (n)***	***Concordance Rate (%)***
Squamous Cell Carcinoma	22	25	88%
Adenocarcinoma	12	15	80%
Tuberculosis	20	28	71%
Inflammatory Lesions	16	20	80%

The data shows a high degree of concordance between cytology and histopathology across all diagnostic categories, indicating good diagnostic reliability of cytology. **Squamous cell carcinoma** exhibited the highest concordance rate at **88%**, suggesting strong cytological diagnostic accuracy. **Adenocarcinoma** and **inflammatory lesions** showed moderate agreement at **80%** each, while **tuberculosis** had the lowest concordance (**71%**), possibly reflecting diagnostic overlap or sampling limitations. Overall, the findings support the usefulness of cytology as a preliminary diagnostic tool, particularly in malignant conditions.

Table 4: Lesion Distribution by Bronchoscopic Access

Lesion Location	***Brush Successful (n)***	***Biopsy Successful (n)***	***Both Successful (%)***
Central	36	40	90%
Peripheral	32	36	78%
Subsegmental	20	24	65%

The data reflects varying success rates of bronchoscopic techniques across lesion locations. **Central lesions** showed the highest dual success rate (**90%**), indicating excellent accessibility for both brushing and biopsy. **Peripheral lesions** had a slightly lower combined success (**78%**), while **subsegmental lesions** had the lowest rate (**65%**), likely

due to technical limitations in accessing more distal airways. These findings underscore the importance of lesion location in planning diagnostic bronchoscopic procedures.

Table 5: Outcome-Based Diagnostic Concordance

Modality	*Final Diagnosis Confirmed*	*Missed Cases*	*Concordance (%)± SD*	
Brush Cytology	68	8	89.5% ± 3.2	***f= 13.88***
Wash Cytology	54	14	79.4% ± 4.5	***p<0.005***
Biopsy Histology	92	3	96.8% ± 2.1	

Table 5 highlights a statistically significant difference in diagnostic concordance among the three modalities (**$f = 13.88$, $p < 0.005$**). **Biopsy histology demonstrated the highest concordance** with the final diagnosis (**96.8% ± 2.1**), reaffirming its role as the gold standard. **Brush cytology** followed with **89.5% ± 3.2%** concordance, indicating good diagnostic reliability. **Wash cytology**, while less accurate (**79.4% ± 4.5%**), still contributed meaningfully but with more missed cases. These findings underscore the superior accuracy of tissue-based diagnosis, while also emphasizing the utility of cytological methods in initial assessments.

DISCUSSION

The present study elucidates the diagnostic performance of bronchial washings (BW), bronchial brushings (BB), and bronchial biopsy in the evaluation of lung lesions, affirming their individual and collective utility within bronchoscopic protocols. The findings demonstrate substantial congruence with existing literature, reinforcing the established roles of these modalities in respiratory diagnostics.

The study cohort demonstrated a male predominance, with 60% of participants identifying as male. Additionally, 45% belonged to the 41–60 year age group, and the mean age was 53.03 ± 14.81 years. This pattern aligns with established demographic trends in lung lesion studies, where male predominance is a recurrent observation.

Supporting literature underscores this trend: Mahajan et al [14] reported 79% male participants in a 100-case series; Raiza et al [15] documented a male-to-female ratio of 6:1; Sushanthi et al [16] observed 69% males with a ratio of 1.5:1 in malignant cases; Bandyopadhyay et al [17] similarly noted 79% males among lung cancer patients. Kedige and Dinesh [18] reported 61.67% males and a ratio of 1.6:1, consistent across studies. This consistent overrepresentation of males is frequently attributed to the higher prevalence of smoking and greater occupational exposure among men.

The study's age distribution, with a peak incidence in the 41–60 year group and a mean age of 53.03 years, aligns with well-established trends. Raiza et al [15] Reddy et al [19] and Sushanthi et al [16] reported similar mean ages ranging from 50 to 60 years, while Bandyopadhyay et al [17] and Mufti & Mokhtar [20] identified predominant age groups spanning the fifth to eighth decades. These findings reinforce the broader understanding that lung lesions especially malignancies are more prevalent among older adults.

Cough was the most common symptom (86%) in this study, significantly associated ($p<0.005$), followed by hemoptysis (30%) and dyspnea (24%). This symptom profile is consistent with other studies. Reddy et al [19] found cough of long duration and chest pain as common symptoms, with hemoptysis and shortness of breath also noted. Mrudula et al [21] similarly reported cough and dyspnea as leading clinical features, followed by chest pain and hemoptysis. These symptoms are classic presentations of lung pathologies, particularly malignancies.

Squamous Cell Carcinoma (SCC) was identified as the most common malignancy (25 cases)**,** followed by Adenocarcinoma (AC) (15 cases) and Small Cell Carcinoma (SCLC) (12 cases). This finding is supported by Mahajan et al [14] who also found SCC to be predominantly diagnosed (19 cases out of 36 malignant). Raiza et al [15] similarly reported 21 SCC cases out of 23 malignant cases confirmed by biopsy, and Choudhury et al [22] noted SCC as the most common malignancy (18 out of 21 cases). Bandyopadhyay et al [17] also found SCC to be the most prevalent (47.4%), followed by adenocarcinoma (23.7%) and SCLC (15.8%).

The superior performance of biopsy in this study, was similar in other study by Bandyopadhyay et al [17] and Mrudula et al [21] concluded that **endobronchial biopsies along with bronchial brush give better cellularity and yield** compared to bronchial wash, and noted that the **probability of finding histological subtypes is higher in endobronchial biopsy** compared to brush and wash samples.

In the present study, brush cytology demonstrated a high concordance rate of 89.5%, underscoring its diagnostic reliability. This is supported by Mahajan et al [14] who reported a BB positivity rate of 63.2%, significantly surpassing that of washings, and concluded that BB is comparably effective to biopsy ($p > 0.05$). Saklain et al [23] also emphasized BB's diagnostic superiority, attributing its high sensitivity to direct lesion sampling.

Additional studies corroborate these findings:

- Bandyopadhyay et al [17] reported BB sensitivity of 74.36% and specificity of 81.82%, noting significant differences compared to pre- and post-biopsy washings.
- Choudhury et al [22] found BB sensitivity at 80.9%, specificity at 85.7%, and accuracy at 82.8%, highlighting superior cytomorphological features such as nuclear detail and chromatin clarity.
- Mufti and Mokhtar [20] observed a sensitivity of 82.1% and overall accuracy of 80%, while Biney et al [24] reported BB sensitivity at 85%.

These consistent findings across studies reinforce bronchial brushing as a reliable, high-yield technique, particularly for the diagnosis and morphological classification of lung malignancies.

Also, lower concordance rate for wash cytology (79.4%) is consistent with many other sources that indicate its more limited utility for malignancy compared to brushings or biopsy: Multiple studies underscore the limited diagnostic value of bronchial washings (BW) in the evaluation of suspected lung malignancies. Mahajan et al [14] reported a BW positivity of just 18.4%, with minimal detection of malignant cases and a higher yield for non-neoplastic lesions. Biney et al [24] echoed these findings, citing an overall sensitivity of 40% and noting that BW did not contribute additional diagnostic benefit over other modalities such as bronchial brushing (BB), prompting recommendations against its routine use. Further, Mrudula et al [21] observed malignancy detection in only 11.8% of BW samples, attributing this to poor representation of malignant cells. Reddy et al [19] described BW as inferior to BB in both cellular preservation and diagnostic contribution. Choudhury et al [22] reported BW sensitivity of 47.6%, specificity of 71.4%, and overall accuracy of 57.1%, emphasizing lower cellularity and suboptimal morphology compared to BB.

In this study, **central lesions showed the highest success (90% for both brush and biopsy), peripheral slightly lower (78%), and subsegmental the lowest (65%)**. This reflects the **general challenge of accessing more distal airways.**

CONCLUSION

This comprehensive evaluation meaningfully contributes to the existing body of evidence on bronchoscopic diagnostic techniques. The findings reaffirm bronchial biopsy as the definitive gold standard due to its consistently high concordance across lesion types and anatomical sites. Consistent with prior literature, the study highlights the robust diagnostic reliability of bronchial brushings, which frequently approach the efficacy of biopsy—particularly valuable when biopsy is contraindicated or technically challenging.

Although bronchial washings alone demonstrate comparatively lower diagnostic yield for malignant lesions, their adjunctive role remains important. Several sources emphasize that when combined with brushings or biopsy, washings enhance overall diagnostic sensitivity and provide cytological clarity in non-neoplastic or inflammatory contexts.

The impact of lesion location on diagnostic success—clearly delineated in this investigation—is a pivotal consideration for procedural planning, influencing the selection and sequence of sampling techniques. Looking ahead, the integration of advanced molecular assays with cytological specimens may further strengthen early diagnostic capabilities and enable precise tumor profiling, opening avenues for individualized therapeutic interventions.

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AUTHOR CONTRIBUTIONS:-

R. Sowmya and *Sridevi M* were responsible for the conceptualization, visualization, and overall administration of the study. *R. Sowmya* contributed to data curation and the initial drafting of the manuscript, while *Sridevi M* oversaw validation and formal analysis. Both authors were actively involved in the manuscript revision process and have approved the final version for submission.

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