Diagnostic Performance of Bronchoscopy in Pulmonary Lesions: A Three-Year Experience from a Regional Referral Center

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Abstract- Bronchoscopy plays an important role in the diagnosis of pulmonary lesions, yet institutional data from regional Indonesian hospitals remain limited. This retrospective study evaluated the diagnostic performance of bronchoscopy and described the clinicopathological profile of patients who underwent the procedure at Sembiring General Hospital from January 2022 to December 2024. A total of 182 patients were included, consisting of 142 males and 40 females, with malignancy detected in 48 cases. Squamous cell carcinoma was the most frequent malignant subtype, predominantly affecting older male patients. Diagnostic yield was influenced by specimen strategy, with multimodal sampling, particularly combinations that incorporated forceps biopsy, showing higher positivity than cytology alone. Statistical analysis demonstrated a significant association between specimen combination and diagnostic outcome. Ancillary procedures such as fine needle aspiration and tumor excision provided confirmation in selected non diagnostic cases. In conclusion, multimodal sampling enhances the diagnostic value of bronchoscopy and supports its role in the evaluation of suspected pulmonary malignancy.

***Index Terms-*:** bronchoscopy, cytology, biopsy, lung cancer.

I. Introduction

Lung lesions encompass a heterogeneous spectrum of malignant and non-malignant pulmonary abnormalities that require comprehensive diagnostic evaluation to guide clinical management. Bronchoscopy has emerged as a central modality for this purpose due to its combined ability to provide direct airway visualization and to obtain diagnostic tissue. Although conventional bronchoscopy remains historically important, its diagnostic performance for small and peripheral lesions is limited, with yields reported to fall below 20% for distal pulmonary lesions.[1,2] Continuous technological advancements have sought to address these limitations and are particularly relevant given the global burden of lung cancer, which remains a leading cause of cancer-related morbidity and mortality worldwide and requires timely diagnostic confirmation.

Recent innovations such as electromagnetic navigation bronchoscopy (ENB), radial endobronchial ultrasound (R-EBUS), and robotic-assisted bronchoscopy have demonstrated improved diagnostic yields, in some settings exceeding 70%.[3–7] The incorporation of cytological and histopathological techniques has further strengthened the diagnostic utility of bronchoscopy. Immunohistochemistry and molecular testing allow for refined tumor classification and therapeutic stratification in lung malignancies.[8,9] Despite these clinical advances, several challenges persist. Diagnostic accuracy continues to be influenced by sampling adequacy, lesion heterogeneity, and false-negative outcomes, particularly in peripheral or mixed neoplastic lesions.[10-13] In addition, cytological examinations such as bronchoalveolar lavage (BAL) and bronchial brushing may produce inconsistent diagnostic yields when compared with forceps biopsy histopathology, reflecting differences in cellularity and tissue architectural detail. Although international studies have reported varied outcomes, comparative real-world data describing the performance of multiple bronchoscopic sampling techniques remain limited and are often institution specific. This gap in the literature restricts broader clinical interpretation and highlights the need for contextual evidence.

This knowledge gap is more evident in regional referral settings within developing healthcare systems, where diagnostic practices, resource availability, and patient characteristics may differ from those reported in larger tertiary institutions. Sembiring General Hospital serves as a referral center for pulmonary and oncologic cases in Deli Serdang Regency. However, local data that describe the clinicopathological features of pulmonary malignancies or that compare the diagnostic performance of BAL cytology, bronchial brushing cytology, and forceps biopsy histopathology have not been documented. Accordingly, the present study aims to evaluate the application of bronchoscopy in the diagnostic assessment of pulmonary lesions within a regional referral hospital in Deli Serdang Regency, to characterize the clinicopathological features of pulmonary malignancies, and to

compare the diagnostic performance of bronchoalveolar lavage cytology, bronchial brushing cytology, and forceps biopsy histopathology in detecting malignant pulmonary lesions.

II. Methodology

This retrospective observational study was conducted at Sembiring General Hospital, a referral center for pulmonary and oncologic cases in Deli Serdang Regency, Indonesia. The study population included all patients who underwent bronchoscopy accompanied by bronchoalveolar lavage (BAL) cytology, bronchial brushing cytology, both cytological modalities, and/or histopathological examination obtained through forceps biopsy during the period of January 2022 to December 2024. Patients without cytological or histopathological specimens were excluded from the analysis. No age or sex restrictions were applied in order to reflect real-world institutional practice. Bronchoscopic procedures were performed following institutional protocols, and cytological as well as histopathological specimens were processed using standard laboratory techniques.

Cytological slides were examined independently in a double-blind manner by two board-certified pathologists. Discrepant interpretations were reviewed and resolved by consensus. Cytological diagnoses were classified according to the WHO Reporting System for Lung Cytopathology. Histopathological diagnoses were established using conventional microscopic examination and supplemented with immunohistochemistry when indicated. For analytical purposes, cases categorized as suspicious for malignancy were considered diagnostic but were not included in malignant subtype analysis. Diagnostic outcomes were further dichotomized into diagnostic and non-diagnostic categories based on WHO classification. Non-diagnostic categories included non-diagnostic, negative for malignancy, and atypical findings, while diagnostic categories encompassed inflammatory lesions, suspicious for malignancy, and malignant neoplasms. Ancillary diagnostic procedures such as fine needle aspiration biopsy and pleural fluid cytology performed subsequent to bronchoscopy were documented as confirmatory investigations and did not alter the primary bronchoscopy-based diagnostic categorization.

Recorded variables were limited to age and sex. Descriptive statistics were used to summarize demographic characteristics. Comparative diagnostic performance across BAL cytology, bronchial brushing cytology, and forceps biopsy histopathology was evaluated using cross-tabulation, and findings were subsequently analyzed statistically. A two-tailed significance approach was applied, and data analysis was performed using standard statistical software.

The study received approval from the institutional ethics committee of Sembiring General Hospital. Patient confidentiality was maintained through anonymization of all data prior to analysis, and informed consent was waived due to the retrospective nature of the study and the absence of direct patient interaction, consistent with ethical practices in retrospective cytopathology research.

III. RESULT

A total of 182 patients underwent bronchoscopy during the study period from 2022 to 2024. The cohort consisted of 142 males and 40 females. Based on cytological and histopathological assessment, 13 cases were categorized as non-diagnostic, 90 cases were negative for malignancy, 8 cases were classified as atypical, 13 cases demonstrated specific inflammatory processes, 10 cases were categorized as suspicious for malignancy, and 48 cases were confirmed as malignant neoplasms. These distributions are clearly illustrated in the pie chart provided below.

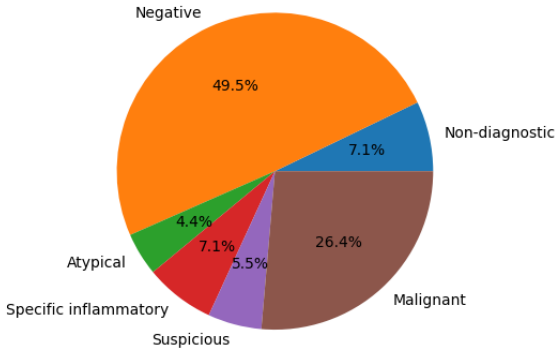

Figure 1. Distribution of bronchoscopy-derived lung cytology results according to the WHO reporting categories (n = 182)

The age of patients undergoing bronchoscopy ranged from 19 to 75 years. The most common age group was 51–60 years, comprising 64 patients, followed by the 61–70 year age group with 50 patients. Malignancies were most frequently identified in the 61–70 year age group. Male patients accounted for the majority of malignant cases, representing 40 of the 48 patients diagnosed with malignancy.

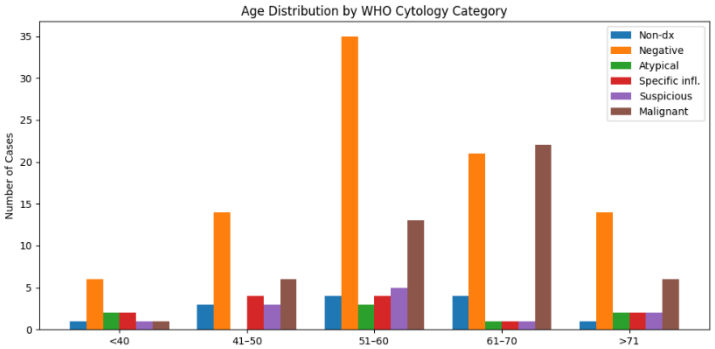

Figure 2. Age distribution of patients (n=182) stratified by WHO lung cytology categories.

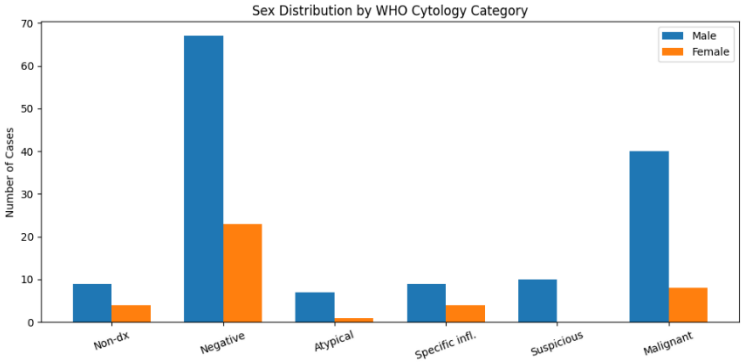

Figure 3. Sex distribution of patients (n=182) stratified by WHO lung cytology categories.

Malignant diagnoses identified through bronchoscopy comprised 48 cases, with squamous cell carcinoma as the most frequent subtype (n=26; 54.2%), followed by adenocarcinoma (n=20; 41.6%) and non-small cell carcinoma, undetermined (n=2; 4.2%). Small cell carcinoma and metastatic tumors were not detected during the study period. Distribution of subtype frequencies is presented in the bar chart below.

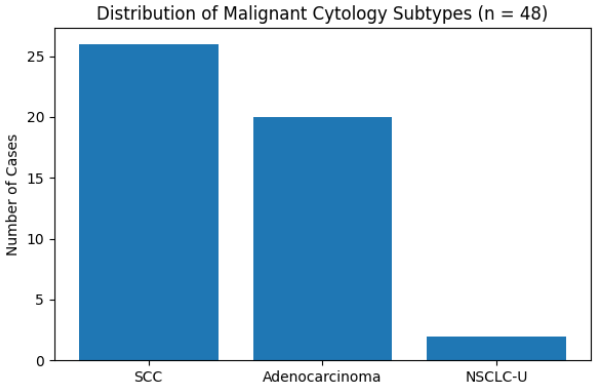

Figure 4. Distribution of malignant cytology subtypes obtained via bronchoscopy (n = 48).

Further analysis of age distribution showed a predominance of malignant cases in the 61–70 year age group (n=22), followed by the 51–60 year group (n=12) and the >71 year group (n=6). When stratified by sex, squamous cell carcinoma occurred more frequently in males (24 of 26 cases), whereas adenocarcinoma demonstrated a comparatively higher proportion in females (5 of 20 cases), although males remained the majority overall. Complete distributions according to age and sex are displayed in the clustered bar charts that follow.

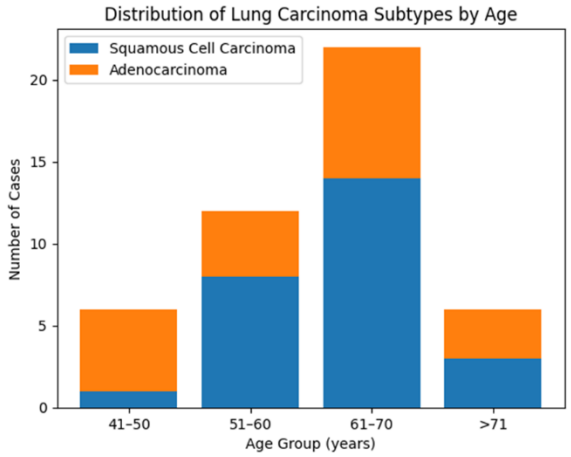

Figure 5. Distribution of lung carcinoma subtypes by age group demonstrates an increasing number of cases in older age decades, with the highest frequency observed in the 61–70-year age group. Squamous cell carcinoma represents the predominant subtype across nearly all age groups (n = 46).

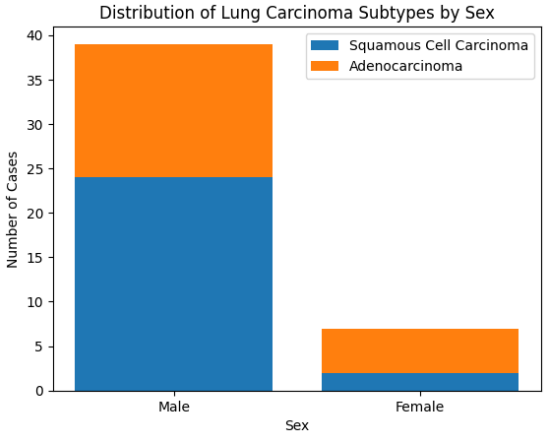

Figure 6. Distribution of lung carcinoma subtypes by sex shows a marked predominance of cases among males, with squamous cell carcinoma occurring more frequently than adenocarcinoma (n = 46)

Diagnostic yield differed according to specimen combination. Cytological techniques alone demonstrated lower diagnostic positivity, with BAL yielding 4 of 42 cases (9.5%) and bronchial brushing yielding 2 of 12 cases (16.7%). The addition of forceps biopsy resulted in higher positivity, with BAL combined with forceps biopsy yielding 27 of 31 cases (87.1%) and brushing combined with biopsy yielding 2 of 4 cases (50.0%). The triple combination of BAL, brushing, and forceps biopsy yielded diagnostic results in 9 of 13 cases (69.2%). Overall, 71 of 182 patients (39%) were diagnostic, while 111 patients (61%) were non-diagnostic. Statistical testing using the Chi-square test demonstrated a significant association between specimen combination and diagnostic outcome ($p < 0.001$). Complete distributions are presented in the bar chart below.

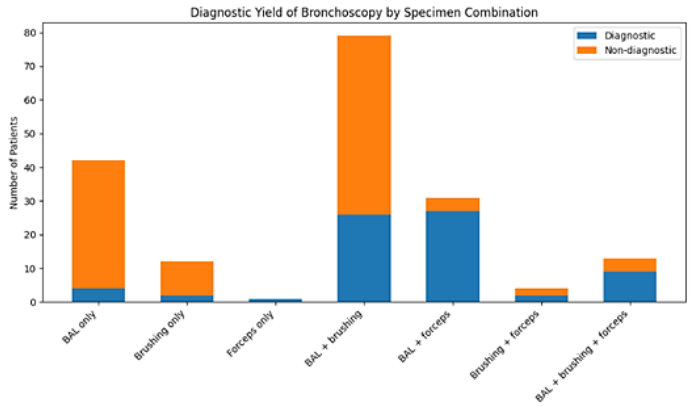

Figure 7. Stacked bar chart demonstrating the diagnostic outcome of bronchoscopy according to specimen combination. BAL and brushing alone showed limited diagnostic performance, whereas combinations including forceps biopsy markedly increased diagnostic yield.

Ancillary diagnostic procedures were subsequently performed in a subset of initially non-diagnostic or non-malignant bronchoscopy cases. A total of 11 patients later received malignancy confirmation through ancillary testing. Fine needle aspiration biopsy confirmed malignancy in 6 cases, including 1 patient initially categorized as non-diagnostic, 4 categorized as

negative for malignancy, and 1 categorized as suspicious for malignancy. Pleural cytology confirmed malignancy in 2 cases, each from the atypical and suspicious categories. Tumor excision confirmed malignancy in 3 cases, including 2 cases initially categorized as negative for malignancy and 1 categorized as specific inflammatory process. The complete distribution of ancillary confirmation across bronchoscopy categories and methods is summarized in the chart below.

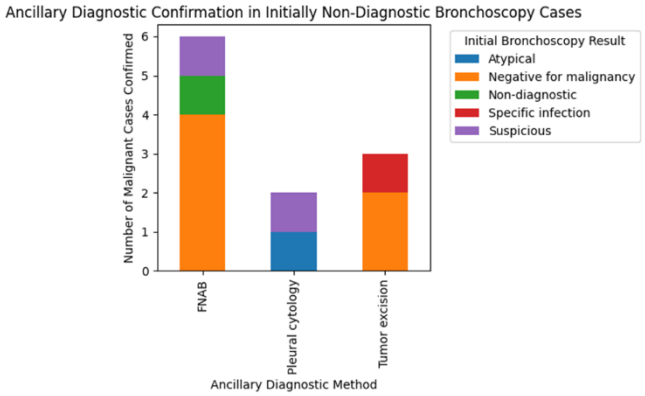

Figure 8. Ancillary diagnostic confirmation of malignancy in cases with initially non-diagnostic or inconclusive bronchoscopy results among patients with lung carcinoma (n = 46). Fine-needle aspiration biopsy (FNAB) accounted for the largest proportion of confirmed malignant cases, followed by tumor excision and pleural cytology, highlighting the diagnostic value of additional procedures after non-definitive bronchoscopic findings.

IV. DISCUSSION

In the evaluation of bronchoscopy cytology specimens using the World Health Organization (WHO) Reporting System for Lung Cytopathology, benign cytological outcomes have consistently emerged as the most frequent diagnostic category, comprising approximately 72.7% to 80.4% of cases in recent cohorts, largely reflecting infectious, inflammatory, and reactive conditions encountered in routine respiratory sampling.[14,15] This distribution corresponds with the system's six-tier diagnostic framework, in which the expected prevalence of categories ranges from 9.3%–18.7% for non-diagnostic, 72.7%–80.4% for benign, 0.6%–2.0% for atypical, 2.1%–2.7% for suspicious for malignancy, and 5.3%–8.0% for malignant specimens, and is accompanied by graded malignancy risks increasing from 31.2% in the benign category to 94.3% in the malignant category.[14-16] Retrospective studies further support this pattern, including a 2024 analysis of 1,520 bronchial washing and brushing specimens demonstrating 9.3% non-diagnostic, 80.4% benign, and 8.0% malignant rates, as well as a 2025 series of 150 cases reporting 72.7% benign and 18.7% non-diagnostic results.[15-17]

When compared with these published cohorts, the present study revealed notable differences in categorical distribution. In our population, benign cytology accounted for 49.5% of cases, which is substantially lower than the benign proportions previously reported. Conversely, the malignant category represented 26.4% of specimens in our series, markedly exceeding the 5.3%–8.0% malignant rates described in recent literature.[14,15,18] This discrepancy likely reflects the higher pretest probability of malignancy within our referral setting, in which bronchoscopy was frequently performed for suspected neoplastic pulmonary lesions. The non-diagnostic category in our study was 7.1%, which appears lower than the 9.3%–18.7% range described in external cohorts, suggesting adequate sampling adequacy within this population. Atypical and suspicious categories also demonstrated modest elevation relative to reference cohorts, emphasizing the diagnostic challenges associated with cytological interpretation of pulmonary lesions and underscoring the necessity for clinicoradiologic correlation, particularly in settings with a high burden of malignancy.

Demographic stratification according to the WHO Reporting System for Lung Cytopathology in our cohort demonstrated a predominance of male patients across all diagnostic categories. This pattern is consistent with findings from multiple institutional cohorts applying the WHO reporting system, which have similarly identified males as comprising approximately 62.7% to 64% of submitted specimens, with the sixth decade representing the most common age group.[14,15] In the present study, male patients accounted for 142 of 182 cases, and the highest frequency of specimens was observed in the 51–60 year age group, followed by the 61–70 year group. Comparable age distributions have been reported in both Indian and Korean retrospective series, where benign and non-diagnostic categories predominated among middle-aged patients, while malignant and suspicious categories were more frequently encountered in older adults.[14,15]

The higher burden of malignancy among older males in our cohort parallels global epidemiological trends in lung cancer, wherein non-small cell lung carcinoma predominantly affects males in the sixth and seventh decades and is influenced by established exposures such as tobacco use and chronic inflammatory airway disease.[17,19] In our study, malignant cytology was most frequently identified in patients aged 61–70 years, with males comprising the majority of malignant cases (40 of 48 patients). Similar demographic skewing toward older males within malignant and suspicious-for-malignancy categories has been observed in Korean and Indian cohorts applying the WHO system.[14,15] In contrast, atypical and suspicious categories in other populations have demonstrated a relatively higher proportion of females, often associated with adenocarcinoma-predominant patterns and earlier age at presentation, although such trends were less pronounced in the present study.[17,19]

When compared with published WHO-based bronchoscopic cytology cohorts, the benign category in our population was proportionally lower, whereas malignant cases were proportionally higher. This divergence likely reflects differences in case-mix, particularly the referral-based enrichment for radiologically suspected neoplasms in our institution. The overall demographic distribution observed in this study reinforces the applicability of the WHO reporting system across diverse clinical populations and highlights the continued relevance of demographic context—particularly age and sex—in the interpretation of cytologic categories and associated malignancy risk stratification.[14,18]

Among malignant lesions identified in this study, squamous cell carcinoma (SCC) accounted for the majority of cases, followed by adenocarcinoma and a smaller proportion of non-small cell carcinoma not otherwise specified. This distribution is consistent with reports demonstrating SCC as the most frequent

histological subtype diagnosed via bronchoscopy, reflecting its anatomical predilection for central airways that are readily visualized and accessible for endobronchial sampling.[20-25] Multiple contemporary cohorts have reported SCC comprising approximately 37–50% of bronchoscopically confirmed lung cancers, with diagnostic yields exceeding 80% in visible endobronchial lesions.[20,21,23] The predominance of SCC within bronchoscopic series is supported by its pathogenesis, in which smoking-related squamous metaplasia progresses within proximal bronchi, generating exophytic or obstructive endoluminal masses that facilitate forceps biopsy and brushing cytology.[21,23,26] In contrast, adenocarcinoma, which constituted the second most common subtype in our cohort, typically arises from peripheral parenchyma and demonstrates lower diagnostic yield with conventional bronchoscopy, often requiring navigational bronchoscopy or transthoracic needle techniques for optimal detection.[19,23]

Regional data from Indonesia reinforce these findings, with recent series from Medan and Cirebon similarly demonstrating higher SCC detection rates among bronchoscopy-confirmed malignancies, particularly in older male smokers presenting with hemoptysis or obstructive symptoms.[19-21] International cohorts likewise note that small cell carcinoma and other less common histologies are underrepresented in bronchoscopic studies, reflecting both sampling limitations and the relative scarcity of central lesions in some tumor types.[24,25] The predominance of SCC in the present study therefore aligns with established bronchoscopic selection patterns, wherein central airway tumors are preferentially captured owing to favorable anatomical accessibility and high-yield multimodal sampling strategies. Collectively, these observations underscore the continued diagnostic value of bronchoscopy in confirming centrally located malignancies within routine clinical practice, particularly in resource-limited settings where rapid histopathologic confirmation informs staging, management, and therapeutic decision-making.[19-27]

When malignant subtypes were further stratified by age and sex, squamous cell carcinoma (SCC) exhibited a clear predominance among older male patients, whereas adenocarcinoma showed a relatively more balanced distribution across sex and age groups. In the present study, SCC was most frequently diagnosed in the 61–70 year age group, accounting for 14 of 26 SCC cases. A similar pattern has been reported across multiple demographic studies wherein SCC shows peak incidence in males aged 60–79 years and demonstrates a strong association with tobacco exposure.[28,29] Male predominance is additionally consistent with global registry data, in which SCC typically displays male-to-female ratios approximating 2:1 or higher and disproportionately affects older men due to cumulative carcinogenic exposure and central airway tropism.[28,29] In our cohort, 24 of 26 SCC cases were male, which aligns with these epidemiological trends.

Adenocarcinoma, the second most common subtype identified in this study, demonstrated a comparatively broader age distribution and a modest female representation. Although adenocarcinoma in our cohort was still predominantly observed in males, with 15 of 20 cases, the proportion of female patients (5 of 20 cases) was greater than that observed for SCC, consistent with recent epidemiological shifts indicating increasing female incidence in adenocarcinoma relative to SCC.[19,30,31] International and regional datasets have likewise documented rising adenocarcinoma incidence among females aged under 60 years and in the sixth decade of life, reflecting both changes in tobacco consumption patterns and the impact of non-smoking-related risk factors that disproportionately affect women.[30,31] Similar associations have been reported in Indonesia, where adenocarcinoma is increasingly recognized in younger female patients and corresponds to imaging findings of peripheral parenchymal lesions.[19]

Taken together, the demographic profile observed in this study reinforces established distinctions between SCC and adenocarcinoma in terms of age, sex distribution, and etiologic associations. SCC remains predominantly a disease of older male smokers with centrally located tumors, whereas adenocarcinoma demonstrates a more heterogeneous demographic distribution and a gradual shift toward greater female involvement. These patterns correspond with the preceding discussion on bronchoscopic subtype predominance, wherein SCC is preferentially identified due to central airway accessibility, while adenocarcinoma, despite being the most common lung cancer subtype globally, may be underrepresented in bronchoscopy-based cohorts due to its peripheral growth patterns.

Evaluation of diagnostic performance based on specimen combination demonstrated that multimodal sampling substantially increased the diagnostic yield of bronchoscopy in our cohort. While cytological techniques such as BAL or bronchial brushing alone showed limited diagnostic utility, the addition of forceps biopsy markedly enhanced performance, with the highest positivity observed in combinations incorporating biopsy. These findings reinforce the complementary nature of cytologic exfoliative sampling and histologic tissue acquisition, particularly in malignant lesions where architectural features, keratinization patterns, stromal desmoplasia, and glandular differentiation are essential for definitive subtype classification.

Recent patient-based analyses from multiple centers similarly indicate that triple-modal sampling—BAL, brushing, and forceps biopsy—achieves the highest diagnostic yield, ranging from 85.7% to 94.1%.[32-34] A study from Ulin General Hospital reported positivity rates of 85.7% for the triple combination, exceeding BAL + forceps (71.4%) and other dual-modality approaches, with adenocarcinoma and squamous cell carcinoma as predominant histotypes.[32] Comparable results were shown in a 2025 retrospective cohort where triple sampling achieved 88% positivity (sensitivity 87.5%, PPV 93.33%), outperforming BAL + biopsy (75%) and BAL + brushing (85%), highlighting the additive diagnostic value of integrating cytology and tissue biopsy for centrally located tumors.[33] Single modalities consistently yielded lower performance, with BAL alone and brushing alone ranging between 44–77%, whereas forceps biopsy alone achieved 71.7–91%, but still benefited from cytology supplementation in dual- or triple-mode sampling.[26,34]

Mechanistically, forceps biopsy provides histologic detail critical for distinguishing SCC from adenocarcinoma, while brushing and BAL contribute enhanced cellularity and exfoliative material from obstructive and submucosal tumor fronts. The improved performance of forceps-inclusive combinations is well-documented, with increases of 13.9–20% in diagnostic positivity over cytology-alone strategies.[33,35] A recent Indonesian cohort

noted that forceps-inclusive procedures increased positivity from 63.6% to 75%, with triple sampling achieving 85.7% despite no demographic variation.[32] Global evaluations further support such strategies, with visible lesions reaching 90–95% positivity using combined techniques, compared to 50–70% for single-modality sampling.[36] These findings position triple-modality sampling as a practical gold standard for visible bronchoscopic lesions in malignancy-enriched populations, particularly within healthcare systems where optimizing first-pass diagnostic procedures is clinically advantageous.

In our setting, specimen combination was significantly associated with diagnostic outcome, supporting the role of multimodal sampling in enhancing the diagnostic utility of bronchoscopy in suspected lung cancer. Statistical evaluation using the chi-square test demonstrated a strong association between specimen combination and diagnostic yield ($p < 0.001$), indicating that the probability of diagnostic success increases when cytology and forceps biopsy are obtained during the same session. Clinically, such strategies minimize false-negative results, reduce the need for repeated bronchoscopy, and facilitate timely histologic subtyping while preserving tissue for immunohistochemistry and potential molecular assays. The improvement in diagnostic yield with forceps-inclusive combinations underscores the importance of procedural planning in malignant lesions, emphasizing that cytology and biopsy are not interchangeable but synergistic approaches within the diagnostic algorithm for lung cancer.

Despite the improved diagnostic yield achieved through multimodal bronchoscopic sampling, a subset of cases in our cohort remained non-diagnostic and required ancillary confirmatory tests to establish a final malignancy diagnosis. A total of 11 patients with initially non-diagnostic or falsely negative bronchoscopy results were subsequently confirmed as malignant through cervical fine-needle aspiration (FNAB), pleural cytology, or tumor excision. This pattern underscores the role of ancillary methods as a complementary extension of bronchoscopy, particularly in settings where clinical and radiologic suspicion for lung cancer remains high.

Cervical FNAB represented the most frequent ancillary confirmation in non-diagnostic bronchoscopy cases. FNAB is widely recognized as a first-line approach for evaluating cervical or supraclavicular lymphadenopathy in suspected metastatic lung cancer, with reported sensitivities of 89–100% and specificities of 96–100%. Its minimally invasive nature, outpatient feasibility, and high diagnostic accuracy allow FNAB to resolve 70–95% of suspicious cervical lymph nodes without necessitating repeat bronchoscopy or surgical biopsy.[37] Pleural cytology contributed confirmations in cases where effusion was present, although its sensitivity is more variable, with pooled rates of 58–75%, reflecting marked histologic variation—adenocarcinoma demonstrating the highest pleural positivity (lung cancer-specific yield 75–79%), whereas squamous cell carcinoma and mesothelioma show substantially lower detection rates.[38,39] Tumor excision biopsy, while providing near-definitive diagnostic yield (95–100%), was employed selectively in our cohort and typically reserved for cases in which cytology-based modalities were either not feasible or diagnostically inconclusive.[40]

The patterns observed in our cohort are concordant with prior reports demonstrating that non-diagnostic bronchoscopy does not preclude malignancy. Studies have noted that 74–96% of patients undergoing surgical biopsy after non-diagnostic bronchoscopy are ultimately confirmed to have malignancy, influencing subsequent management decisions.[40,41] Likewise, FNAB has been shown to detect cervical metastatic involvement in 24–34% of lung cancer patients, with accuracy approaching 90–100%, particularly when guided and in the presence of PET-avid nodal disease.[37] Pleural cytology, particularly when supplemented by cell block preparation, improves diagnostic yield by 10–15%, while closed biopsy and VATS-based excision further enhance malignant pleural effusion detection to 85–90%.[38,39]

From a clinical perspective, these findings support a tiered diagnostic strategy in which bronchoscopy serves as the primary modality for central lesions, while ancillary testing provides confirmatory resolution in non-diagnostic or ambiguous cases. Importantly, the need for ancillary confirmation in our cohort complements the earlier demonstration that multimodal bronchoscopic sampling significantly improved diagnostic success, as evidenced by the statistically significant association between specimen combination and diagnostic outcome (chi-square test, $p < 0.001$). Such structured integration minimizes false-negative rates, reduces procedural repetition, and expedites subtype confirmation, while preserving sufficient material for immunohistochemistry and, when indicated, molecular studies.

Taken together, our findings illustrate that bronchoscopy operates not as a stand-alone diagnostic endpoint, but as a pivotal component within a broader pathological workflow in lung malignancy. Ancillary cytologic and surgical methods offer critical downstream resolution in patients with high pretest likelihood of cancer, ensuring that diagnostic certainty can still be achieved following initial non-diagnostic bronchoscopic evaluation.

This study has several inherent limitations. The retrospective single-center design may limit generalizability, particularly in the absence of standardized radiologic stratification of lesion location or bronchoscopic visibility, both of which influence sampling strategy and diagnostic yield. Multimodal sampling was not uniformly applied, and the small number of forceps-only and triple-sampling cases restricts comparative analysis between specimen combinations. Ancillary confirmation was performed selectively rather than protocolized, and the lack of systematic longitudinal follow-up raises the possibility of underestimating false-negative cytologic categories. Furthermore, downstream molecular profiling and staging implications were not assessed, despite their growing relevance in contemporary lung cancer pathways.

Future research should focus on prospective multicenter validation of multimodal bronchoscopic sampling, integrating standardized radiologic parameters and predefined ancillary algorithms for initially non-diagnostic cases. Comparative evaluations of diagnostic yield stratified by cytologic WHO categories, lesion morphology, and demographic variables may refine risk stratification and assist in procedural triage. Incorporating molecular testing and treatment-related endpoints would also clarify the clinical impact of bronchoscopic diagnosis in modern oncology practice. Ultimately, research aimed at optimizing first-pass diagnostic strategies is essential to reduce procedural delays, minimize repeat interventions, and improve care pathways in suspected lung malignancy.

V. CONCLUSION

This study provides clinicopathological data on patients who underwent bronchoscopy for evaluation of pulmonary lesions at Sembiring General Hospital from January 2022 to December 2024. The findings showed that the majority of cases fell within benign-equivalent diagnostic categories based on the WHO Reporting System for Lung Cytopathology, while malignant neoplasms were predominantly observed in older male patients. Squamous cell carcinoma constituted the most frequent malignant subtype detected through bronchoscopy, followed by adenocarcinoma, consistent with the higher diagnostic visibility of centrally located tumors.

The study also demonstrated that diagnostic performance was strongly influenced by the type of specimen obtained. Cytological modalities such as BAL and brushing alone provided limited diagnostic utility, while the incorporation of forceps biopsy substantially increased positivity rates. Multimodal sampling offered a complementary diagnostic advantage, reducing non-diagnostic outcomes and enabling more accurate histologic subclassification. In selected initially non-diagnostic cases, ancillary procedures such as fine-needle aspiration and tumor excision provided final malignancy confirmation, indicating an important stepwise role for adjunctive diagnostic approaches. From this retrospective study, we suggest that:

1. Optimization of multimodal bronchoscopic sampling: Combined cytological and histological sampling should be considered for suspected malignant pulmonary lesions to improve first-pass diagnostic yield and reduce repeat procedures.
2. Integrated diagnostic pathways: Ancillary procedures such as cervical or supraclavicular fine-needle aspiration may be utilized when bronchoscopy yields uncertain or non-diagnostic results, particularly in the presence of clinically suspicious lymphadenopathy.
3. Strengthening local diagnostic capability: Forceps biopsy remains essential for histologic confirmation and subtyping, underscoring the need for adequate biopsy instruments and procedural planning within bronchoscopy units.
4. Further research: Prospective multicenter studies incorporating standardized lesion visibility, imaging parameters, and downstream staging or molecular testing are recommended to validate these findings and improve diagnostic accuracy in lung cancer pathways.
5. Clinical awareness and early evaluation: Older male patients with relevant clinical symptoms or risk factors may benefit from early bronchoscopic evaluation to facilitate timely diagnosis and appropriate oncologic management.

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