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## Diagnostic accuracy of cytology in the evaluation of lung lesions

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### Abstract

**Introduction:** Bronchoalveolar lavage (BAL) and bronchial brushing (BB) are routinely used cytological techniques for evaluating lung lesions. With the rising incidence of lung cancer, cytology has assumed a central role in the diagnostic workup of pulmonary lesions. This study aimed to evaluate the diagnostic accuracy of BAL, BB, and their combined use in the assessment of lung lesions, using histopathology as the gold standard.

**Method:** This prospective study was conducted in the Department of Pathology at Patan Academy of Health Sciences, Nepal, from February 2025 to January 2026. A total of 98 cases with paired BAL, BB, and lung biopsy specimens were included. Diagnostic performance parameters, including sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy, were calculated for BAL, BB, and combined cytology.

**Result:** The study population consisted predominantly of males (69.38%), with a mean age of 63.3 years. Squamous cell carcinoma was the most common malignant diagnosis. Sensitivity was highest for combined cytology (62.50%), followed by BB (57.14%) and BAL (36.73%). Specificity was high for all modalities. Combined cytology demonstrated the highest diagnostic accuracy (78.57%), followed by BB (77.55%) and BAL (67.35%). Concordance between cytology and histopathology for malignant lesions was 63.41%.

**Conclusion:** Lung cytology demonstrates high specificity but limited sensitivity. Consequently, negative results—especially with BAL—should be interpreted cautiously and correlated with clinical, radiological, and histopathological findings. Cytological evaluation of lung lesions alone is insufficient to exclude malignancy.

**Keywords:** Bronchoalveolar lavage; Cytodiagnosis; Lung neoplasm



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## Introduction

Bronchoalveolar lavage (BAL), bronchial brushing (BB), and bronchoscopy-guided lung biopsies are diagnostic tools used routinely in the evaluation of both non-neoplastic and neoplastic lung lesions.<sup>1</sup> With the increase in the incidence of lung cancer worldwide, the cytological evaluation of suspected lung lesions has taken a central role in the diagnosis. An added advantage of BAL and BB is the ability to assess peripheral lung lesions that cannot be accessed by bronchoscopy.<sup>2</sup> Bronchial cytology plays a diagnostic role not only in evaluating lung malignancy but also in diagnosing non-neoplastic lesions, such as pulmonary alveolar proteinosis, eosinophilic pneumonia, and infectious pathologies, among others.<sup>3</sup> In countries with low-resource settings, such as Nepal, where advanced bronchoscopic techniques and fluoroscopy are not readily available, bronchial cytology plays a pivotal role. The diagnostic yield is highest for bronchial biopsy, followed by BB and BAL, respectively.<sup>4</sup>

Therefore, this study was conducted to evaluate the diagnostic accuracy of BAL, BB, and their combined use in diagnosing lung lesions, using histopathological examination of lung biopsy as the gold standard. This is particularly relevant in low-resource settings like Nepal, where advanced bronchoscopic techniques and fluoroscopy are not widely available, and reliable cytological methods remain essential for early and accurate diagnosis.

## Method

This prospective study was conducted in the Department of Pathology at Patan Academy of Health Sciences, Lalitpur, Nepal, from February 2025 to January 2026 after ethical clearance from the institutional review committee of Patan Academy of Health Sciences (Ref. drs2502141986). A sample size of 44 was calculated using Buderer's formula, assuming the sensitivity of 67.00%, specificity of 80.00% and prevalence of 64.00%.<sup>5</sup> All patients whose BAL BB and lung biopsy were sent to the Department of Pathology, Patan Academy of Health Sciences, were included in the study after obtaining consent. However, all consecutive eligible cases with complete paired specimens available during the study period were enrolled, resulting in a total of 98 cases, thereby enhancing the statistical strength and reliability of the findings.

The smears of both BAL and BB were fixed with

methanol, and a few slides were air-dried. Methanol-fixed slides were stained with Papanicolaou stain, and air-dried slides with Giemsa stain. The lung biopsy specimens were fixed in 10.00% formalin and sections were prepared and stained with hematoxylin and eosin stain. Cytological and histopathological evaluation of the slides were performed independently by the principal investigator and co-investigators, with each observer blinded to the results of the other modality. Data entry was done in Microsoft Excel 2016. The collected data were analysed with IBM SPSS Statistics software version 20. The nominal variables included age, gender, and frequency of lung lesions. The sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of BAL and BB and a combination of BAL and BB (cytology) were calculated using histopathology as the gold standard. The concordance between cytology and histopathology was determined by observation of the concordance table.

## Result

A total of 98 cases were included in the study. Among them, 68(69.38%) cases were male and 30(30.62%) cases were female. The age range of the patients was from 21 to 90 years, with a median age of 64 years and a mean age of 63.3 years, Table 1.

**Table 1. Distribution of cases according to age and gender**

Age group	Male	Female	Total f (%)
21-30	3	1	4(4.08%)
31-40	3	3	6(6.12%)
41-50	2	5	7(7.14%)
51-60	14	5	19(19.38%)
61-70	18	8	26(26.53%)
71-80	19	7	26(26.53%)
81-90	9	1	10(10.20%)
Total	68(69.38%)	30(30.62%)	98(100.00%)

The most common malignant diagnosis on histopathology was squamous cell carcinoma, followed by non-small cell carcinoma, small cell carcinoma, and adenocarcinoma, respectively. Cytology demonstrated the highest sensitivity, followed by BB, while BAL showed the lowest sensitivity among the three diagnostic modalities. However, BAL and BB exhibited higher specificity than that of cytology, Table 2.

The diagnostic performance of BAL, brushing, and cytology show high PPV. In contrast, the NPV were comparatively lower, particularly for BAL. Regarding overall diagnostic accuracy, cytology showed the

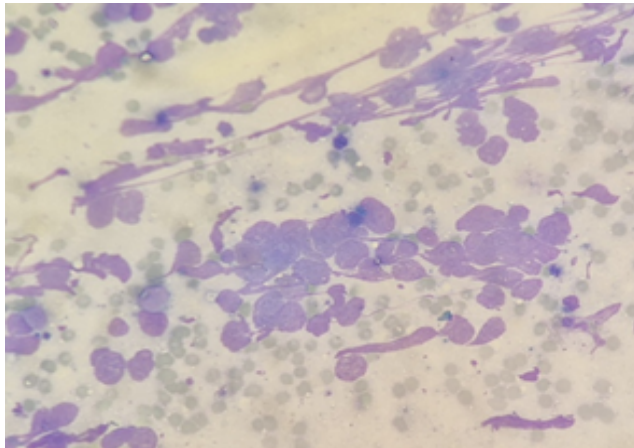
**Table 2. Sensitivity, specificity, PPV, NPV, accuracy of BAL, bronchial brushing, and cytology**

	Sensitivity	Specificity	PPV	NPV	Accuracy
BAL	36.73	97.96	94.74	60.76	67.35
Bronchial brushing	57.14	97.96	96.55	69.57	77.55
Cytology (BAL+BB)	62.5	94	90.91	72.31	78.57

**Table 3. Concordance between cytology and histopathology**

Cytology	Histopathology							Total
	TB	NFM	Suspicious	Sq cell CA	Adeno CA	Small cell CA	Non-small cell CA	
TB	4	0	0	0	0	0	0	4
NFM	3	47	2	5	3	2	3	65
Suspicious	1	0	0	1	0	0	0	2
Sq cell ca	0	2	0	5	0	0	0	7
Adeno ca	0	0	0	0	3	0	0	3
Small cell ca	0	0	0	0	0	6	0	6
Non-small cell ca	0	0	2	2	0	0	7	11
Total	8	49	4	13	6	8	10	98

\*TB: tuberculosis, NFM: negative for malignancy, Suspicious: suspicious for malignancy, Sq cell ca: squamous cell carcinoma, Adeno ca: adenocarcinoma, Small cell ca: small cell carcinoma, Non-small cell ca: Non-small cell carcinoma



**Figure 1. BB smears of small cell carcinoma with tumor cells showing scant cytoplasm, granular nuclear chromatin, nuclear moulding and crushing artefact. (Giemsa stain, 40X)**

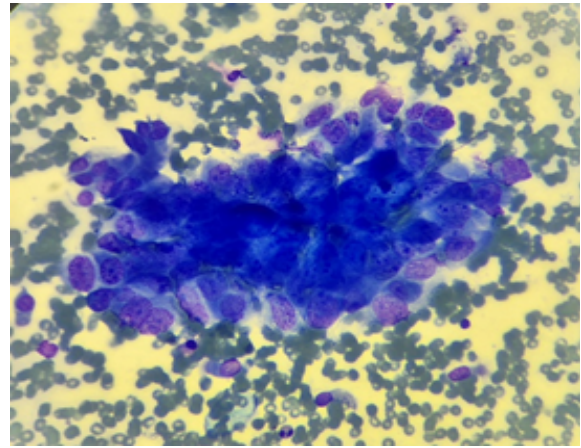
highest accuracy, closely followed by brushing, while BAL had lower accuracy.

An overall concordance rate of 63.41% was observed between cytology and histopathology for the diagnosis of malignant lung lesions. Concordance was highest in cases of adenocarcinoma and small cell carcinoma (100.00% each), while squamous cell carcinoma demonstrated a concordance of 71.40%, Figure 1 and Figure 2. In contrast, a lower concordance rate of 50% was observed for the diagnosis of tuberculosis.

## Discussion

Cytological evaluation offers a rapid, minimally invasive assessment, while biopsy provides definitive confirmation. The combined use of cytology, such as BAL and BB, and biopsy enhances diagnostic accuracy compared with individual modalities.<sup>6</sup>

In the present study, BAL had the lowest sensitivity, however, this finding does not limit its diagnostic value. BAL has an established role in identifying non-neoplastic and inflammatory lung conditions such as acute eosinophilic pneumonia, pneumoconiosis, pulmonary alveolar proteinosis, diffuse alveolar hemorrhage, etc.<sup>7,8,9</sup> A large proportion of cases in our series were neoplastic, a setting in which BAL may have reduced sensitivity due to limited tumor cell shedding into the air spaces. In comparison, BB



**Figure 2. BB smears of adenocarcinoma. The tumor cells are arranged in clusters and demonstrate pleomorphism. The individual tumor cells have high nuclear to cytoplasmic ratio with coarse chromatin and multiple conspicuous nucleoli. (Giemsa stain, 40X)**

consists of direct brushing of the mucosal surfaces, providing a higher diagnostic yield.<sup>8,10</sup> Gaur et al.<sup>11</sup> and Tomar et al.<sup>12</sup> observed a sensitivity of BAL of 39.40% and 47.61%, respectively. The increase in sensitivity with combined BAL and BB suggests a complementary role.<sup>2,13,14</sup> The high specificity of BAL, BB, and cytology in this study is in conjunction with that of other studies.<sup>6,8,15</sup> This suggests that combining these diagnostic techniques may reduce the overall false-negative results.

The false negative results in this study were predominantly due to inadequate cell exfoliation, with other reasons including peripherally located lesions and inflammatory cells masking the tumor cells. Similar findings were observed by Fariba et al.<sup>16</sup> and Goel et al.<sup>1</sup> There were two false positive cases in our study, both of which were misdiagnosed as squamous cell carcinoma. Retrospective evaluation showed the presence of squamous epithelial cells with reactive atypia and extensive squamous metaplasia, causing misinterpretation. A study by Joana et al.<sup>17</sup> showed that BB demonstrated higher sensitivity but an increased false positive result.

BB demonstrated the highest PPV, followed by BAL and cytology, indicating that when these tests yield a positive result, they are highly reliable in confirming the presence of disease. However, a negative result,

especially with BAL, does not exclude the disease and should be interpreted with caution. Ahmed et al.<sup>18</sup> found the PPV of BAL to be 100.00%. Wannasai et al.<sup>19</sup>, in their study, had a PPV of 71.90%, whereas another study found it to be 67.40%.<sup>1</sup> BB showed a PPV ranging 90.00% to 100.00%.<sup>1,8</sup>

Our study showed NPVs of 60.76%, 69.57%, and 72.31% for BAL, BB, and cytology, respectively. This finding is similar to those of Chodankar et al.<sup>20</sup> and George et al.<sup>8</sup>, who demonstrated NPVs of 60.26%, 64.86%, and 71.21% for BAL and BB, respectively. This highlights the importance of combining diagnostic methods or correlating results with clinical, radiological, and histopathological findings to reduce false-negative diagnoses.

The diagnostic accuracy of BAL and BB in the studies by Chodankar et al.<sup>20</sup> and George et al.<sup>8</sup> was 69.61% and 64.86%, respectively, for BAL, and 81.37% and 70.27%, respectively, for BB. The increase in the diagnostic accuracy observed with the combined use of BAL and BB further underscores the importance of integrating these techniques.

The limitations of this study include small sample size with study population being predominantly elderly males, reflecting the epidemiology of lung cancer, hence limiting the diagnostic variability. Hence, non-neoplastic or inflammatory lesions were not adequately evaluated.

## Conclusion

The combined use of BAL and BB improves the detection of lung pathologies compared with either technique alone, aiding earlier diagnosis and patient management. The limited sensitivity of cytology in the diagnosis of lung lesions indicate that negative results do not exclude malignancy and hence, correlation with clinical, radiological, and histopathological findings remain essential for accurate diagnosis.

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## Conflict of Interest

None

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## Author Contribution

Concept, design, planning: MS, DG, GS, PS1, AR, PS2, AM; Literature review: MS; Data collection: MS, PS2, AM; Data analysis: MS, DG, PS2, AM; Draft manuscript: MS, PS1, AR; Revision of draft: MS, DG, GS, PS1, AR; Final manuscript: MS, DG, GS, PS1, AR, PS2, AM; Accountability of the work: MS, DG, GS, PS1, AR, PS2, AM; Guarantor: MS.

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