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Original Research Article

Sputum Cytology: The Simplest and Emphatic Modality in Diagnosis of Lung Carcinoma and Its Radiological Correlation

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Abstract

Background: Lung cancer remains one of the leading causes of cancer-related mortality worldwide. Early diagnosis plays a crucial role in improving patient outcomes. Sputum cytology is a simple, non-invasive, economical, and easily repeatable diagnostic modality that provides valuable cytomorphological information. It is particularly useful in patients who are unfit for invasive procedures such as bronchoscopy or transthoracic needle aspiration.

Methods: This retrospective study was conducted in the Department of Pathology, Government Medical College, and Saharanpur over six years (2018–2024). A total of 113 symptomatic patients presenting with radiological abnormalities were evaluated. Three consecutive morning sputum samples were collected from each patient. PAP, Giemsa, and Ziehl–Neelsen staining were performed. The cytological findings were correlated with chest X-ray and CT chest when available. Sensitivity and specificity of sputum cytology were calculated based on malignant vs. non-malignant diagnostic outcomes.

Results: Among 113 patients, sputum cytology detected malignant cells in 39 (34.51%) patients—34 males and 5 females. Squamous cell carcinoma was the most common subtype (18 cases; 46.15%), followed by small cell carcinoma (12; 30.77%), adenocarcinoma (7; 17.95%), and large-cell carcinoma (2; 5.13%). Sputum cytology showed a sensitivity of 100% (all confirmed malignancies detected cytologically) and specificity of 90.54% for excluding malignancy in non-cancer cases. Central lung masses on chest X-ray correlated significantly with squamous cell and small cell carcinomas.

Conclusion: Sputum cytology is a highly effective, low-cost, safe, and reliable diagnostic method for early detection and subtyping of lung carcinoma. It is particularly beneficial in elderly and clinically unstable patients where invasive diagnostic procedures are contraindicated.

Keywords: Sputum Cytology, Lung Carcinoma, Radiological Correlation.

Introduction

Lung cancer is one of the major global health burdens and remains the leading cause of cancer-related deaths. Its prognosis depends largely on the stage at which it is diagnosed. However, due to vague early symptoms and limited access to advanced diagnostic facilities, a significant proportion of cases are detected late. [1,2] Sputum cytology, a form of exfoliative cytology, offers a simple, safe, and non-invasive tool for diagnosing lung cancer by evaluating exfoliated malignant cells from the bronchial epithelium. [3,4,5] It has demonstrated high diagnostic utility particularly in centrally located tumors, such as squamous cell carcinoma and small cell carcinoma. [6,7,8] Despite newer modalities like bronchoscopy, CT-guided biopsy, and EBUS, sputum cytology continues to have considerable value—especially in settings where invasive procedures are risky, unavailable, or unaffordable. [9,10,11] This study evaluates the diagnostic efficacy of sputum cytology in lung cancer, correlates cytological findings with radiological features, and calculates sensitivity and specificity using 6 years of retrospective data.

Materials and Methods

This retrospective observational study was conducted on data between January 2018 – December 2024 at Department of Pathology, Government Medical College, and Saharanpur. A total of 113 patients participated in this study.

Inclusion Criteria

- Age > 35 years
- Both sexes
- Patients presenting with chest symptoms and radiological lesions (consolidation, nodules, cavitation, mass lesions)

Exclusion Criteria

- Age < 35 years
- Pregnant women

Sputum Sample Processing: Early morning deep-cough sputum samples were collected for three consecutive days in sterile containers. The sample were then strained using any of the following strains: PAP stain, Giemsa stain or Ziehl-Neelsen stain (for Acid-Fast Bacilli). Two trained pathologist made the diagnosis and in case of any differences.

Radiological Evaluation: Chest X-ray was performed for all patients and chest CT scan for 14 patients.

Statistical Analysis: Data was collected for analysis with the help of Microsoft excel and statistical analysis was performed using Python (v3.9) and its libraries, including NumPy (v1.24), Pandas(v1.3.5), and Seaborn (v0.11.2). A p-value <0.05 was considered significant.

Observations & Results

The majority of cases were male (71.69%), indicating a strong male predominance in patients presenting with suspected lung pathology. Distribution of cases based on gender is presented in Table 1.

Table 1: Gender-wise case distribution (n=113)

Sex	Number	Percentage
Male	81	71.69%
Female	32	28.31%
Total	113	**100%**

Most patients belonged to the 46–67-year age group, reflecting the typical age range for lung cancer incidence. Distribution of cases based on age is presented in Table 2.

Table 2: Age-wise case distribution (n=113)

Age Group	Total (%)	Male (%)	Female (%)
35–45	11 (9.73%)	8 (7.10%)	3 (2.65%)
46–56	47 (41.60%)	33 (29.20%)	14 (12.38%)
57–67	39 (34.51%)	27 (23.89%)	12 (10.61%)
68–77	9 (7.96%)	7 (6.19%)	2 (1.77%)
>78	7 (6.20%)	6 (5.31%)	1 (0.88%)

Upon analysing the clinical features, Table 3, highlights the most common symptoms, with productive cough and hemoptysis being the leading clinical presentations.

Table 3: Distribution of Clinical Features based on Gender

Clinical Feature	Male	Female	Total (%)
Smoking	58	7	65 (57.52%)
Dry cough + chest pain	32	11	43 (38.05%)
Productive cough + hemoptysis	62	18	80 (70.79%)
Productive cough + chest pain	48	10	58 (51.33%)
Breathlessness	37	12	49 (43.36%)
Asymptomatic	8	3	11 (9.73%)

The most frequent radiological abnormalities detected, Table 4, were mass lesions with or without cavitation and fibro cavitary changes.

Table 4: Distribution of X-Ray Findings based on Gender

X-Ray Findings	Male	Female	Total (%)
Mass + cavitation	21	2	23 (20.35%)
Mass without cavitation	8	4	12 (10.62%)
Nodules	7	1	8 (7.08%)
Collapse	2	0	2 (1.77%)
Consolidation	6	1	7 (6.19%)
Pleural effusion	7	1	8 (7.08%)
Fibrocavitary lesions	17	9	26 (23.01%)
Prominent broncho-vascular markings	13	14	27 (23.89%)

Squamous cell carcinoma was the most common malignant subtype identified, Table 5, followed by small cell carcinoma and adenocarcinoma.

Table 5: Distribution of Sputum Cytological Diagnosis Findings (N=39)

Cytological Diagnosis	N (%)
Squamous cell carcinoma	18 (46.15%)
Small cell carcinoma	12 (30.77%)
Adenocarcinoma	7 (17.95%)
Large cell carcinoma	2 (5.13%)

Most non-malignant cases showed inflammatory infiltrates or fungal infections, while 7 cases, Table 6, were AFB-positive for tuberculosis.

Table 6: Radio-Cytological Correlation (N=39)

Cytological Type	Total	Mass	Nodules	Consolidation	Collapse	Pleural Effusion
Squamous cell carcinoma	18	14	1	2	1	1
Small cell carcinoma	12	8	1	1	2	0
Adenocarcinoma	7	1	3	1	0	1
Large cell carcinoma	2	1	0	0	1	0
Total	**39**	**24**	**5**	**4**	**4**	**2**

Sensitivity and Specificity Calculation: Confusion matrix for the case is presented as Figure 1. As all 39 cancers were detected cytologically, thus no false negatives. AFB-positive cases excluded from malignancy diagnosis but radiologically suspicious.

Table 7: Confusion Matrix for the diagnosis made Cytological (N=113)

		Observed	
		True	**False**
Actual	**True**	39	0
	False	7	67

Following formulas were used for sensitivity and Specificity calculation,

Sensitivity = _____True Positives_____

True Positives + False Negatives

Specificity = _____True Negatives _____

True Negatives + False Positives

Upon substituting the value, sensitivity came out as 100% and specificity as 90.54%.

Discussion

The present six-year retrospective study reaffirms the enduring value of sputum cytology as a fundamental diagnostic tool in the initial workup of suspected lung carcinoma, particularly in resource-conscious settings.

Our findings are consistent with the global epidemiology and diagnostic principles of lung cancer while providing specific insights from our patient population. The detection rate of lung cancer by sputum cytology in our study was 34.51%. This figure aligns with the understood sensitivity of the technique, which is known to be moderate but highly specific [12, 13]. The sensitivity is influenced by tumor location, size, and histology. Our calculated specificity and PPV of 100% are particularly significant.

A positive sputum cytology for malignancy is a highly reliable result, obviating the need for repeat non-invasive tests and directly guiding the clinician towards confirmatory and staging investigations. The sensitivity of 34.51%, while seemingly low, is a realistic reflection of its yield in a mixed cohort of suspicious patients and is consistent with its role as a screening test rather than a definitive rule-out tool [14].

The demographic data revealed a strong male predominance (M:F ratio of 6.8:1 among cancer patients), which is a well-established trend, largely attributable to higher rates of tobacco smoking among males [15, 16]. In our study, 92.3% of male lung cancer patients had a significant smoking history. The peak incidence in the 5th to 7th decades of life is also a classic finding, reflecting the long latency period of carcinogenesis [17, 18, 19].

The distribution of histological subtypes in our cytological analysis offers valuable insights. Squamous cell carcinoma was the most prevalent (46.15%), followed by small cell carcinoma (30.77%) and adenocarcinoma (17.95%). This distribution differs from trends in many Western nations, where adenocarcinoma has surpassed squamous cell carcinoma as the most common type [20]. This discrepancy may be linked to the high

prevalence of smoking and the types of tobacco products consumed in our region, which are more strongly associated with central airways tumors like squamous and small cell carcinomas [21,22]. The high proportion of small cell carcinoma detected is notable and underscores the utility of sputum cytology in identifying this aggressive variant, which requires a distinct, non-surgical treatment approach [23].

The clinical presentation was dominated by respiratory symptoms, with productive cough accompanied by hemoptysis and chest pain being the commonest combination. This aligns with the typical presentation of centrally located tumors that ulcerate and bleed [24]. The 9.73% of asymptomatic patients detected incidentally highlight the potential role of sputum cytology in screening high-risk individuals with abnormal imaging, even in the absence of symptoms.

The radiological-cytological correlation was a cornerstone of our analysis. We found a compelling association: squamous and small cell carcinomas, which are typically central in origin, most frequently presented as a hilar or perihilar mass on X-ray [16, 18]. The tendency for squamous cell carcinoma to cavitate was also observed. Conversely, adenocarcinoma, which often arises in the lung periphery, was radiologically characterized by nodules and pleural effusion, consistent with its known pathological behavior [25].

This correlation is clinically invaluable. A central mass on a chest X-ray in a smoker should heighten the suspicion for squamous or small cell carcinoma, and sputum cytology becomes a very appropriate first test in this scenario.

The limitations of our study are its retrospective nature and the lack of histopathological confirmation in all cases, which precludes a definitive calculation of sensitivity and specificity against a universal gold standard. The performance of CT scans in only a subset of patients is another limitation. Furthermore, the "pick and smear" method, while reliable, may have a lower yield compared to liquid-based cytology or sputum concentration techniques [22, 26].

Despite these limitations, the strengths of our study lie in its substantial sample size over a six-year period and the meticulous correlation of clinical, radiological, and cytological data. It powerfully demonstrates the practical utility of a simple, inexpensive test in a real-world clinical setting.

Conclusion

Sputum cytology remains an emphatic, cost-effective, and reliable non-invasive modality for the diagnosis of lung carcinoma. Its high specificity and positive predictive value make a positive result profoundly significant for patient management. It is particularly effective for diagnosing central tumors, which are often of the squamous or small cell subtype. In a country like India, with a high burden of lung cancer and often constrained healthcare resources, sputum cytology serves as a crucial first-line diagnostic tool. It can expedite the diagnosis, guide further management, and is indispensable for patients who are poor candidates for invasive procedures. While it may not replace bronchoscopy or CT-guided biopsy, it firmly retains its place as a fundamental component of the diagnostic armamentarium against lung cancer.

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