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Original Research Article

Correlation of bronchoalveolar lavage fungal culture with clinical spectrum and radiological features: a retrospective study

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ABSTRACT

Background: Pulmonary fungal infections are an increasingly recognized cause of respiratory morbidity, particularly in immunocompromised individuals and patients with structural lung disease. Clinical and radiological features often overlap with tuberculosis and bacterial pneumonia, making diagnosis challenging. Bronchoalveolar lavage (BAL) based fungal culture and galactomannan assay are important diagnostic tools; however, their clinical relevance requires correlation with presentation and imaging findings.
Methods: This retrospective observational study was conducted in the department of respiratory medicine at tertiary care hospital from June 2025- November 2025. Patient (>18 years) with BAL positivity for fungal culture, galactomannan assay (GM) was included. Clinical characteristics, comorbidities, immunological status and radiological findings on chest radiograph and computed tomography were analyzed. Statistical analysis was performed using IBM SPSS version 25.0. Continuous variables were expressed as mean and categorial variables as percentages. Fischer's exact test was used with $p<0.05$ considered statistically significant.
Results: 78 patients were included mean age 52.7 years. BAL fungal culture was positive in 48 patients, GM assay in 30, and both in 25 patients. Aspergillus species were the most common isolates (53.7%). Diabetes mellitus showed a significant association with fungal culture positivity($p=0.035$). Consolidation was the most frequent radiological finding across all groups, while cavitary lesions were more common in patients positive for both GM and culture.
Conclusions: Aspergillus species predominate in pulmonary fungal infections and are commonly associated with diabetes, post- tubercular lung disease and characteristic radiological patterns. Integrated clinical, radiological and microbiological evaluation is essential for early diagnosis and appropriate management in tuberculosis-endemic region.

Keywords: Fungal, Consolidation, Galactomannan assay

INTRODUCTION

Fungal infection of the lower respiratory tract have become an important cause of morbidity and mortality, especially among individuals with compromised immunity such as those with hematological malignancies, organ transplants, HIV infection, autoimmune diseases receiving immunosuppressive therapy and critically ill patients.[1,2] In recent years, changes in patient demographics, widespread use of broad spectrum antibiotics, corticosteroids, chemotherapeutic agents and invasive medical procedures have contributed to notable rise in both opportunistic and non-opportunistic fungal pmeumonias.[3] Despite this growing burden, the diagnosis of pulmonary fungal disease remains challenging. Clinical manifestations comprised of cough, dyspnea, fever, chest pain, hemoptysis are nonspecific and often indistinguishable from bacterial, viral or

inflammatory lung diseases.[4] Radiological evaluation primarily through high resolution computed tomography (HRCT) plays an important role in diagnostic process; however imaging patterns associated with fungal pneumonia are highly variable. Findings such as ground glass opacities, tree in bud appearance, consolidation, cavitation and classic halo or air crescent sign have been described in invasive fungal infections, but these features are not pathognomonic and may overlap with tuberculosis, malignancy and other infections.[5,6] Bronchoalveolar lavage (BAL) has emerged as a key diagnostic tool because it allow direct sampling from the lower respiratory tract, providing material for fungal culture, microscopy, antigen detection and molecular assays.[7] BAL fungal cultures remain widely used because they are inexpensive, accessible and capable of identifying viable organisms. However, interpretation of culture results is complicated by the possibility of airway colonization or contamination particularly with species such as Candida that frequently inhabit the oropharynx.[8] Thus, differentiating true invasive disease from mere colonization is a major clinical dilemma.

Given these challenges, correlating BAL fungal culture results with clinical features and radiological patterns is essential for improving diagnostic accuracy. Establishing such correlations may help clinicians to determine whether a positive culture reflects true infection and decide when antifungal therapy is warranted. Therefore, this study aims to systematically analyze the relationship between fungal culture positivity, the associated clinical profile and characteristic radiological features in patients with suspected fungal lower respiratory tract infections.

METHODS

Study design and period

This was a retrospective observational study done in group of patients who underwent bronchoscopy and lavage fluid was positive for fungal organism conducted at the Department of Respiratory Medicine, Himalayan Institute of Medical Sciences, Dehradun, from June 2025 to November 2025.

Male and female patients aged over 18 years were incorporated in the study. BAL sample tested for Galactomannan (GM), KOH mount and fungal culture and found to be positive in any one of them were enrolled in the study and correlated with the clinical and radiological presentation in form of Chest Xray and computed tomography (CT) thorax. Associated comorbidity and immunocompetency status were also documented from medical record sheets.

Exclusion criteria

Patients with incomplete records, inadequate BAL samples, prior antifungal therapy, repeat BAL samples, and inconclusive microbiological reports were excluded from the study.

Sample size

The final sample size comprised 78 patients with BAL positivity for fungal organisms. The data was analyzed using appropriate statistical tools. Statistical analysis was done using IBM SPSS Statistics version 25.0. Continuous variable was expressed as mean and categorial variables as counts and percentage Fischer's exact test was done to find out correlation. P value less than 0.05 was statistically significant.

RESULTS

Total 78 patients were included, mean age 52.7 years, 54 were male and 24 were females, male to female ratio – 2.25:1 (Figure 1). Out of 78, 30 were BAL GM positive, 48 were BAL Fungal culture positive, and 25 had positivity for both.

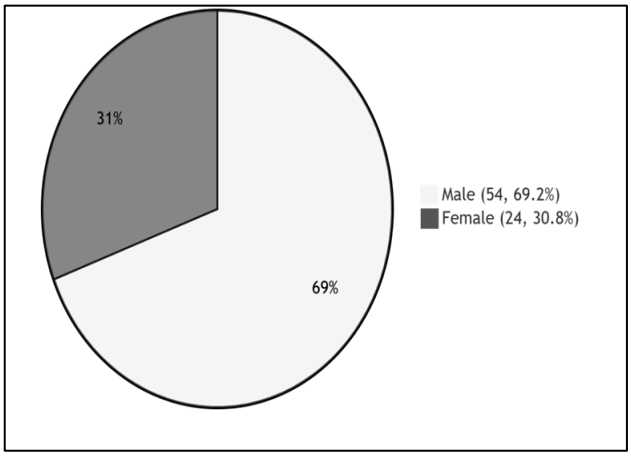

Figure 1: Demographic data of patients.

Clinical characteristics

Among GM positive patients, 53.5% were immunocompromised, 35.5% had diabetes and 27.5% presented with hemoptysis. Similar proportions were observed in culture positive patients, where 53.7% were immunocompromised, 35.2% had diabetes and 25.9% had hemoptysis. Patients with both GM and culture positive demonstrated a higher burden of risk factors with 50% being immunocompromised and 25% had diabetes mellitus (Table 1). Fungal culture positivity showed a statistically significant association with diabetes mellitus (p=0.035). History of smoking and old treated pulmonary tuberculosis was present maximum in fungal culture positive patients (13 and 17) respectively.

Radiological findings

Across all positive groups, consolidation was the most frequent radiological abnormality observed, seen in 77.5%

of galactomannan-positive patients, 64.8% of culture-positive patients, and 81.2% of patients who were positive by both methods. Other commonly observed findings included cavitary lesions, fibrosis/fibro-calcific changes, nodules and pleural effusion. Cavitation was more frequent in patients positive for both GM and culture (50%) suggesting more advanced or invasive disease. A substantial proportion of cases demonstrated mixed or non-specific radiological features

Among fungal culture organism most commonly found was Aspergillus species 53.7% and least was Trichosporon asahii 1.9% (Table 2). Consolidation was most frequently associated with Aspergillus fumigatus and Penicillium, while cavitary lesions, air crescent like appearances in some cases showed a strong association with Aspergillus species, supporting post tubercular or chronic lung disease – related fungal infection.

Table 1: Clinical characteristics and associated risk factors among patients with positive galactomannan (GM), fungal culture, and both GM and culture positivity.

Clinical characteristics	GM positive patients (%)	Culture positive patients (%)	Both GM and culture positive (%)
Immuno-compromised Status	53.5	53.7	50.0
Diabetes mellitus	35.5	35.2	25.0
Haemoptysis	27.5	25.9	—

Table 2: Organism isolated from fungal culture.

Fungal organism	Number of cases
Aspergillus fumigatus	13
Aspergillus flavus	8
Aspergillus niger	5
Aspergillus versicolor	1
Penicillium	14
Fonsecaea pedrosoi	3
Nigrospora species	2
Trichosporon asahii	1
Bipolaris species	1

DISCUSSION

The present study provides a comprehensive clinic microbiological and radiological evaluation of patients with suspected pulmonary fungal infections, highlighting the spectrum of fungal pathogens, their radiological correlated, and associated risk factors such as prior pulmonary tuberculosis and immunocompromised status. Our findings reinforce the growing recognition of pulmonary mycoses as an important and often underdiagnosed cause of chronic respiratory morbidity in tuberculosis endemic regions such as India

Demographic and clinical profile

Pulmonary fungal infections in our cohort predominantly affected middle- aged and elderly individuals which is consistent with earlier Indian and international studies reporting increased susceptibility with advancing age due to declining immunity and pre-existing structural lung disease.[9-11] Male predominance observed in our study mirrors findings from previous reports, likely reflecting higher exposure to environmental fungal spores ,smoking and occupational risk factors among males.[12-13] Similar demographic trends have been documented in studies from India, South east Asia and Africa, emphasizing the universal nature of these risk factors.[14]

Etiological spectrum of fungal pathogens

Aspergillus species constituted the most common fungal pathogen in our study, with Aspergillus fumigatus, Aspergillus flavus and non-speciated Aspergillus collectively accounting for the majority of isolates. This predominance is in concordance with multiple Indian studies that have identified Aspergillus as the leading cause of pulmonary fungal infections, particularly in patients with chronic lung disease and post tubercular sequelae.[15-17] An important observation in our study was the relatively high isolation rate of Penicillium species, which have traditionally been considered contaminants but are increasingly recognized as opportunistic pulmonary pathogens, especially in structurally abnormal lungs.[18] The isolation of dematiaceous fungi such as Fonsecaea pedrosoi and Nigrospora species further underscores the expanding spectrum of pulmonary fungal infections, as also reported in recent Indian and Southeast Asian literature.[19,20]

Radiological correlation

Radiologically, pulmonary consolidation was the most frequent pattern observed, followed by nodules and cavitary lesions. These findings align with previous studies demonstrating that fungal pneumonia often mimics bacterial pneumonia or tuberculosis, leading to diagnostic delay.[21,22] Cavitary lesions were predominantly associated with Aspergillus species, particularly in patients with history of pulmonary tuberculosis, supporting earlier observations that residual cavities serve as a nidus for fungal colonization and invasion.[21]

Nodular patterns were less common but showed a diverse fungal etiology, consistent with reports describing nodular fungal disease as manifestation of airway centered or angioinvasive infection.[22] The presence of non-specific or mixed radiological patterns in a significant proportion of patients highlights the limitations of imaging alone and reinforces the need for microbiological confirmation.

Association with prior pulmonary tuberculosis

A notable proportion of patients in our cohort had a history of treated pulmonary tuberculosis, with Aspergillus species being the predominant isolates in this subgroup. This finding is consistent with previous Indian studies that have reported post tubercular lung disease as one of the strongest risk factors for chronic pulmonary aspergillosis.[21] Structural lung damage, persistent cavities and impaired mucociliary clearance following TB create a favorable environment for fungal colonization and infection.

Given India's high TB burden, this association has significant clinical implications, as persistent or recurrent respiratory symptoms in post TB patients are often misattributed to TB relapse, leading to inappropriate treatment and delayed antifungal therapy.[23]

Galactomannan positivity and its diagnostic utility

Serum galactomannan assay played a crucial role in the diagnostic evaluation of our patients. A significant proportion of patients demonstrated GM positivity either alone or in combination with positive fungal culture results, underscoring its value as non-invasive diagnostic tool. Similar GM positivity rates have been reported in Indian studies evaluating invasive and chronic pulmonary aspergillosis, particularly among patients with prior tuberculosis or chronic lung disease.[24] Conversely GM positivity in culture negative patients highlights the known limitations of fungal culture, including low sensitivity and prolonged turnaround time, as previously emphasized by Denning et al and Agarwal et al.[25]

Clinical implications

The overlapping clinical and radiological features of pulmonary fungal infections with tuberculosis and bacterial pneumonia underscore the importance of early fungal work up, including fungal culture and antigen assays, in patients with non-resolving pneumonia or chronic lung disease. Early recognition is crucial as delayed diagnosis is associated with increased morbidity and mortality.

Limitations

The study is limited by its single center design and relatively small sample size, particularly within specific subgroups such as immunocompromised patients. Despite this limitation the study provides valuable insights into the evolving epidemiology of pulmonary fungal infections in an Indian tertiary care setting.

CONCLUSION

In conclusion our study highlights Aspergillus species as the predominant cause of pulmonary fungal infections with significant associations with post tubercular lung disease and characteristic radiological patterns. Increased awareness, timely microbiological evaluation and high index of suspicion are essential for improving outcomes in patients with suspected pulmonary fungal infections, particularly in tuberculosis endemic regions.

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