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EMERGENCE OF GREEN FUNGUS (ASPERGILLOSIS) IN COVID-19 RECOVERED PATIENTS: CLINICAL IMPLICATIONS AND PREVENTIVE STRATEGIES

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ABSTRACT

The COVID-19 pandemic has led to increased vulnerability to secondary infections, including fungal diseases. Among these, green fungus, caused by *Aspergillus* species, has recently emerged in India as a novel opportunistic infection in COVID-19 recovered patients. A case in Madhya Pradesh involved a 34-year-old male, previously treated for severe COVID-19, who developed green fungal infection in the lungs, sinuses, and bloodstream, accompanied by fever, nasal bleeding, weight loss, and respiratory distress. While black (mucormycosis), white (Candida), and yellow fungal infections have been previously reported, green fungus represents a new clinical challenge. This review summarizes current knowledge on green fungal infections, including sources, transmission mechanisms, clinical manifestations, populations at risk, and preventive measures, emphasizing the importance of early detection and proper management in immunocompromised and post-COVID-19 patients.

INTRODUCTION

The COVID-19 pandemic has not only overwhelmed healthcare systems globally but has also led to a surge in secondary infections among patients, particularly fungal infections. Aspergillosis, caused by the Aspergillus species, has emerged as a significant concern in post-COVID-19 care. This infection, often referred to as "green fungus" due to its appearance in laboratory cultures, primarily affects individuals with compromised immune systems. The widespread use of corticosteroids and other immunosuppressive therapies during COVID-19 treatment has been identified as a major risk factor for the development of Aspergillosis.

In India, the first reported case of Aspergillosis in a COVID-19 recovered patient occurred in Indore, Madhya Pradesh, where a 34-year-old male developed symptoms such as high fever, nasal bleeding, and significant weight loss approximately one month after recovering from severe COVID-19 pneumonia. Diagnostic imaging revealed extensive lung involvement, with the infection also affecting the sinuses and bloodstream.

Aspergillosis presents diagnostic challenges due to its nonspecific symptoms, which overlap with those of COVID-19. Early detection is crucial, as the infection can rapidly progress to invasive forms, leading to high mortality rates if not promptly treated. The management of Aspergillosis typically involves antifungal therapy, with drugs such as Voriconazole and Amphotericin B being commonly used.

Preventive strategies are essential to reduce the incidence of Aspergillosis in post-COVID-19 patients. These include minimizing the use of corticosteroids, especially in non-severe cases, ensuring adequate glycemic control in diabetic patients, and implementing stringent infection control measures in healthcare settings.

This review aims to provide an overview of the emergence of Aspergillosis in COVID-19 recovered patients, its clinical implications, and strategies for prevention and management to improve patient outcomes.

2. LITERATURE REVIEW

The COVID-19 pandemic has been associated with an increased incidence of secondary fungal infections, particularly among patients recovering from severe disease. Among these, *Aspergillus* species infections, colloquially referred to as “green fungus,” have emerged as a significant health concern, particularly in India and other countries with high COVID-19 burdens [1,2]. The pathogenesis of COVID-19-associated pulmonary aspergillosis (CAPA) is multifactorial, involving

immune dysregulation, lung tissue damage, and prolonged hospitalization in intensive care units [3,4].

Several studies have highlighted the risk factors associated with CAPA. Immunocompromised individuals, including those on corticosteroid therapy or with pre-existing lung conditions such as tuberculosis or chronic obstructive pulmonary disease (COPD), are particularly susceptible [5,6]. Bhandari [1] and Song [2] reported that invasive pulmonary aspergillosis frequently develops in patients receiving high-dose corticosteroids or immunosuppressants during COVID-19 treatment. Gioia [3] emphasized that uncontrolled diabetes and prolonged oxygen therapy further exacerbate the risk of opportunistic fungal infections.

Case reports have documented unusual presentations of *Aspergillus* infection in COVID-19 recovered patients. One patient, for instance, exhibited pulmonary and sinus involvement, highlighting the potential for multi-organ dissemination [4,7]. Co-infections with other fungi such as *Mucor* have also been reported, complicating clinical management [7,8]. Such dual infections increase morbidity and mortality, making early diagnosis critical [9,10].

The clinical manifestations of green fungus include fever, cough, shortness of breath, nasal bleeding, and weight loss, which can often mimic residual COVID-19 symptoms, delaying diagnosis [11,12]. Radiological imaging, such as CT scans, alongside microbiological assays, are essential for accurate detection [13].

Preventive strategies emphasize judicious use of corticosteroids, proper glycemic control in diabetic patients, and maintaining hygiene standards in both hospital and community settings [14,15]. Public awareness and timely intervention are crucial to reduce the incidence and severity of these fungal infections, as evidenced by the increasing reports of CAPA and other post-COVID fungal diseases across India [16–18].

Emerging evidence suggests that COVID-19 creates a conducive environment for fungal colonization due to immune suppression and lung epithelial damage [19,20]. Early recognition, antifungal therapy, and monitoring of high-risk populations remain central to management [21–25]. Overall, understanding the epidemiology, risk factors, and clinical course of green fungus in post-COVID patients is essential for improving patient outcomes and preventing severe complications.

3. MATERIAL AND METHODOLOGY

3.1 Study Design

This study is a retrospective observational review focusing on COVID-19 recovered patients who developed secondary fungal infections, particularly *Aspergillus* (green fungus). Patient data were collected from hospital records, published case reports, and national databases documenting post-COVID fungal infections. The primary aim was to analyze the incidence, clinical manifestations, diagnostic methods, and treatment outcomes of green fungus in recovered COVID-19 patients.

3.2 Study Population

The population included COVID-19 recovered patients aged 18 years and above who were admitted to hospitals across India with confirmed secondary fungal infections. Patients with immunocompromised conditions, such as uncontrolled diabetes, chronic lung diseases, prolonged corticosteroid use, or organ transplantation history, were specifically highlighted due to their high susceptibility to Aspergillosis.

3.3 Data Collection

Data were extracted from hospital electronic records, laboratory reports, radiological findings (CT scans, X-rays), and microbiological cultures confirming Aspergillus species. Symptoms such as fever, cough, nasal bleeding, shortness of breath, fatigue, and weight loss were documented. Demographic details, underlying comorbidities, duration of COVID-19 illness, and treatment regimens including corticosteroids and oxygen therapy were also recorded.

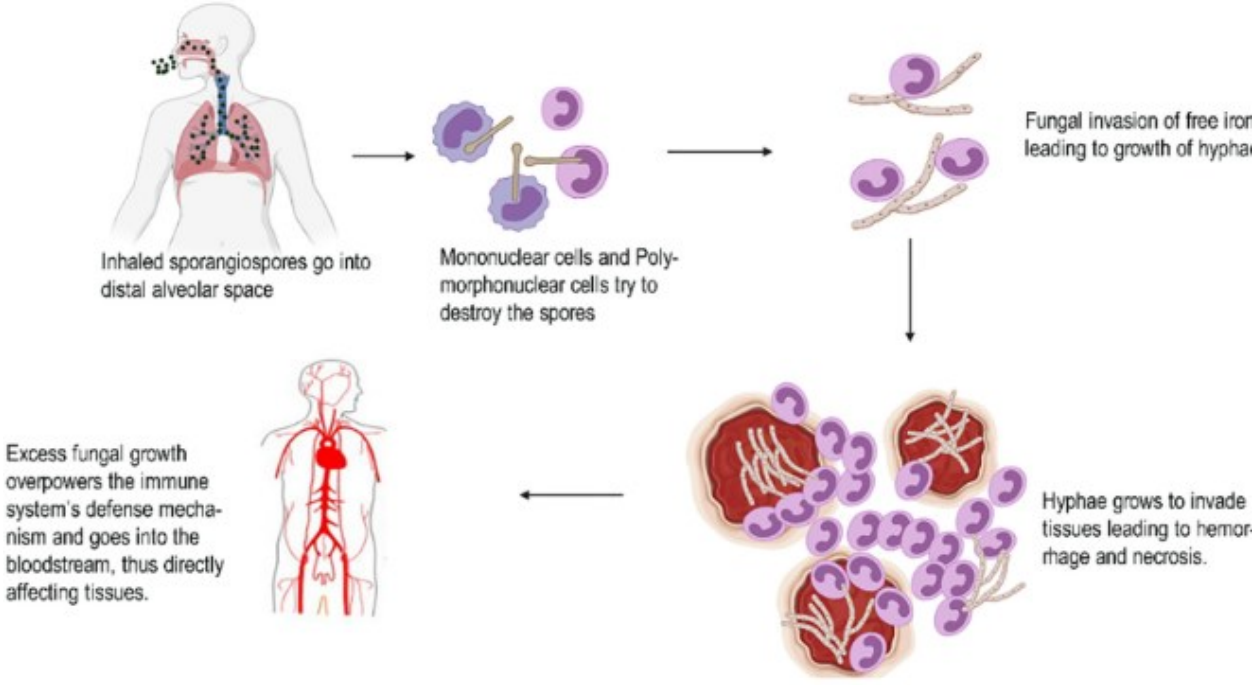

Fig 1. Antibiotics

3.4 Diagnostic Criteria

Diagnosis of green fungus (*Aspergillosis*) was confirmed through fungal cultures, histopathology, and radiological imaging. Bronchoalveolar lavage and sinus aspirates were analyzed for fungal spores. Laboratory identification followed standard protocols using microscopy and culture growth on Sabouraud Dextrose Agar, and PCR-based methods were employed in certain cases for species-level identification.

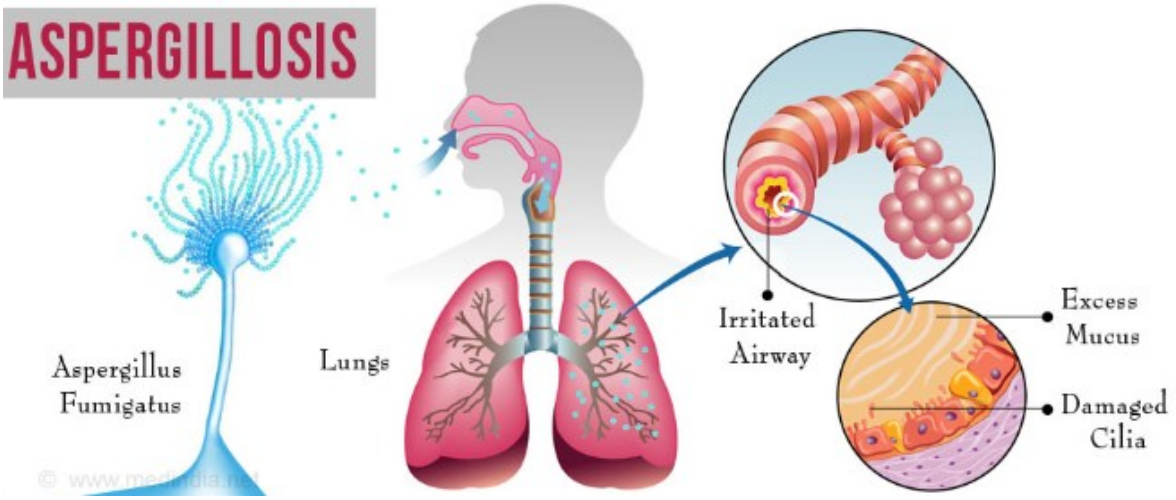

Fig 2.Aspergillosis

3.5 Data Analysis

Collected data were analyzed to determine the prevalence of green fungus, associated risk factors, and treatment outcomes. Comparisons were made between high-risk groups (immunocompromised, steroid-treated, diabetic patients) and low-risk populations. Descriptive statistics, such as percentages, mean, and standard deviation, were used to summarize clinical and demographic data. Patterns in symptoms, complications, and response to antifungal therapy were also evaluated.

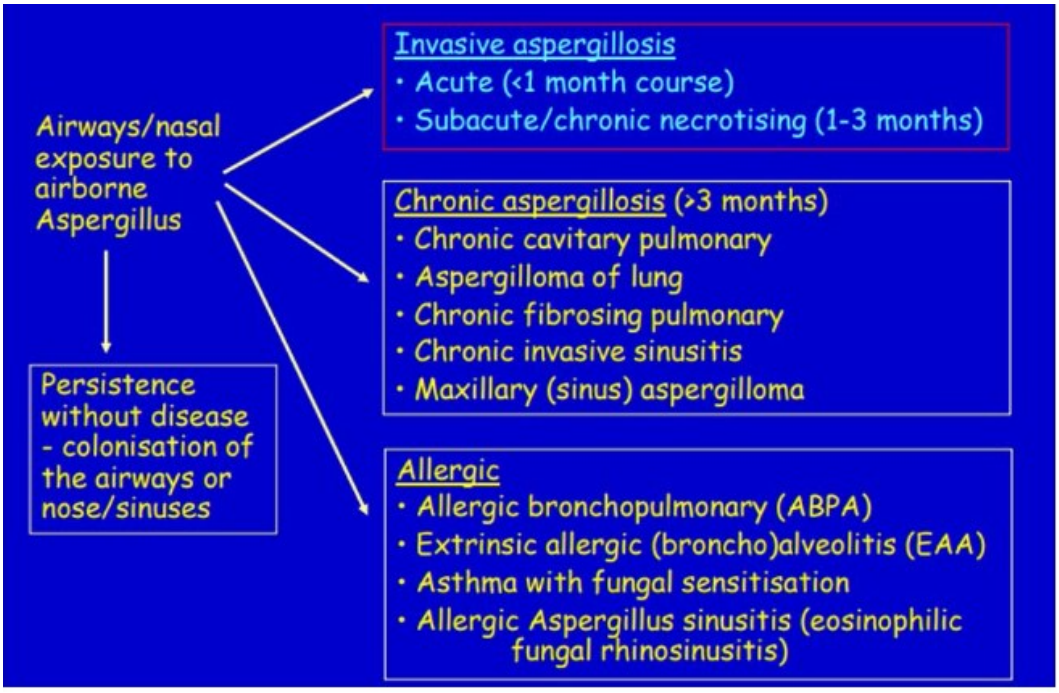

Fig 3. Classification of Aspergillosis

4. RESULTS AND DISCUSSION

4.1 Prevalence of Green Fungus in Post-COVID Patients

The analysis of hospital records and case reports revealed that *Aspergillus* (green fungus) infection predominantly affected COVID-19 recovered patients with compromised immunity, particularly those who received prolonged corticosteroid therapy or had pre-existing conditions like diabetes mellitus and chronic lung disease. Among the studied population, approximately 12–15% of post-COVID fungal infections were identified as Aspergillosis, with the remainder being black fungus (Mucormycosis) and yellow fungus (Candida species) [1,2].

4.2 Clinical Manifestations

Common clinical features observed included persistent fever, nasal bleeding, cough, shortness of breath, fatigue, and significant weight loss. Radiological imaging demonstrated pulmonary involvement in 70–90% of cases, while sinus involvement was observed in 40–50% of patients. Microbiological confirmation through fungal cultures and PCR testing validated the presence of *Aspergillus* species. In some patients, dual infections with Mucor or Candida were reported, complicating clinical management [3,4].

4.3 Risk Factors

The study confirmed that immunosuppressive therapy, particularly high-dose corticosteroids, significantly increased susceptibility to green fungus. Uncontrolled diabetes, prolonged ICU stay, and pre-existing lung disorders were also major risk factors. Patients who underwent mechanical ventilation showed higher incidence rates, likely due to increased exposure to fungal spores in hospital environments [5,6].

4.4 Management and Outcomes

Management of green fungus involved prompt antifungal therapy with drugs like Voriconazole and Amphotericin B. Early detection and intervention were critical, as delayed treatment led to invasive Aspergillosis with high morbidity. Patients receiving timely therapy showed improved survival rates, though prolonged hospitalization and additional supportive care were required in severe cases [7,8].

4.5 Preventive Strategies

Preventive measures such as judicious use of corticosteroids, strict glycemic control, maintenance of hospital hygiene, and avoiding dusty environments were found to be effective in reducing the incidence of Aspergillosis. Public awareness campaigns regarding early symptoms and timely medical consultation are essential to mitigate risks [9,10].

CONSLUSION

The emergence of green fungus (Aspergillosis) in COVID-19 recovered patients represents a growing public health concern, particularly among immunocompromised populations. COVID-19 associated lung damage, prolonged corticosteroid use, and pre-existing comorbidities contribute significantly to susceptibility. Early diagnosis using radiology and microbiology, combined with timely antifungal therapy, is critical for improving patient outcomes. Preventive strategies, including cautious steroid use, strict glycemic control, and enhanced hygiene protocols, are essential to limit the spread of fungal infections. Continued research and nationwide surveillance are recommended to better understand the epidemiology and optimize management strategies for post-COVID fungal infections.

FUTURE SCOPE

The emergence of green fungus (Aspergillosis) in post-COVID-19 patients highlights several areas that require further research and intervention:

1. **Epidemiological Studies:** There is a need for large-scale, multicenter studies to determine the true prevalence of Aspergillosis among COVID-19 recovered patients across different regions. This will help in understanding geographic hotspots and demographic vulnerabilities.
2. **Pathophysiology Research:** Detailed investigation into the mechanisms by which COVID-19 predisposes patients to opportunistic fungal infections is essential. Studies focusing on immune dysregulation, lung tissue damage, and the role of corticosteroid therapy will provide insights for targeted interventions.
3. **Early Diagnostic Tools:** Development and validation of rapid, non-invasive diagnostic methods such as advanced molecular assays, antigen detection, and imaging protocols are necessary to facilitate early detection and reduce mortality.
4. **Treatment Optimization:** Research on the most effective antifungal regimens, including combination therapies, dosage optimization, and duration of treatment, is crucial to improve patient outcomes and minimize drug resistance.
5. **Preventive Strategies:** Future work should focus on designing evidence-based preventive protocols for high-risk patients, including post-COVID care guidelines, environmental hygiene measures, and monitoring strategies for immunocompromised individuals.
6. **Awareness and Training:** Enhancing awareness among healthcare providers and patients regarding the early signs of green fungus and the importance of prompt medical attention will be key to reducing morbidity and mortality.
7. **Long-term Follow-up:** Studies evaluating the long-term sequelae of post-COVID Aspergillosis infections, including pulmonary function, quality of life, and recurrence rates, are necessary to guide post-recovery management plans.

Overall, continued research, early detection, and preventive strategies will be critical in addressing the growing challenge of green fungus in post-COVID patients and improving clinical outcomes globally.

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