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Research Article

MUCORMYCOSIS IN POST– COVID-19 PATIENTS: EMERGING THREAT AND CLINICAL CHALLENGES IN INDIA

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ABSTRACT

Mucormycosis, an opportunistic and aggressive fungal infection caused by fungi of the order *Mucorales*, has emerged as a serious complication in post–COVID-19 patients, particularly in India. The disease is non-communicable but is triggered by inhalation of fungal spores, which are ubiquitous in the environment. The widespread use of corticosteroids in COVID-19 management, coupled with uncontrolled diabetes mellitus and immune suppression, has significantly increased susceptibility. This review consolidates recent literature on the epidemiology, pathophysiology, and clinical management of COVID-19–associated mucormycosis (CAM) in India. It further explores antifungal treatment options such as liposomal amphotericin B, posaconazole, and isavuconazole, while addressing public-health challenges in surveillance and awareness. Early diagnosis and multidisciplinary interventions remain critical for reducing morbidity and mortality. Strengthened health-system preparedness, rational steroid use, and diabetes control are imperative to mitigate future mucormycosis outbreaks in post-pandemic India.

Keywords: COVID-19, Mucormycosis, Diabetes mellitus, Fungal infection, Corticosteroid therapy.

INTRODUCTION

The emergence of mucormycosis as a severe secondary infection in COVID-19 patients has presented a new clinical and public-health challenge in India. Commonly known as “black fungus,” mucormycosis is caused by filamentous fungi of the genera Garg *et al* (2021) The infection primarily affects immunocompromised individuals, particularly those with uncontrolled diabetes mellitus or prolonged corticosteroid exposure Singh *et al* (2021). During the second wave of COVID-19 (April–June 2021), India reported a sharp increase in COVID-19–associated mucormycosis (CAM) cases, accounting for over 47,000 infections and more than 4,300 deaths. This surge was attributed to the combined effect of immune dysregulation by SARS-CoV-2, steroid misuse, and high prevalence of diabetes among the Indian population. The estimated prevalence of mucormycosis in India (14 per 100,000 population) is approximately 70 times higher than the global average. Globally, mucormycosis has been reported in COVID-19 patients with a history of intensive care admission, mechanical ventilation, or broad-spectrum antibiotic use. However, India’s tropical climate, socioeconomic disparities, and limited access to tertiary fungal diagnostic facilities further amplify disease incidence. This review synthesizes evidence from 2015–2024 to analyze epidemiological trends, risk factors, clinical manifestations, diagnostic protocols, and therapeutic strategies of post–COVID-19 mucormycosis, with emphasis on prevention and policy implications.

A systematic review by Garg *et al.* (2021) reported over 100 confirmed CAM cases across 18 countries, with India contributing more than 80% of total cases. V. Muthu *et al.*

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(2021) performed a meta-analysis identifying diabetes mellitus (80%) and corticosteroid therapy (76%) as predominant risk factors. Muthu *et al.* (2021) highlighted that the mortality of pulmonary mucormycosis remains between 45–65%, with little improvement over time despite antifungal advances. Saldanha *et al.* (2021) described paranasal mucormycosis as the most common form, followed by rhino-orbital-cerebral involvement, which rapidly invades vascular and neural tissues. John *et al* (2021) emphasized that early surgical debridement coupled with antifungal therapy significantly improves survival. Moorthy (2021) reported orbital compartment syndrome and vision loss in severe COVID-19 patients due to fungal angioinvasion.

Szarpak (2021) termed the interaction between SARS-CoV-2 infection, diabetes, and steroid therapy as the "perfect storm" for Steinbrink and Miceli (2021) outlined that mucormycosis pathogenesis involves endothelial invasion, thrombosis, and tissue necrosis. Moorthy (2021) demonstrated fatal pulmonary mucormycosis in a patient with hematologic malignancy, underscoring its link with immunosuppression. Zurl (2021) in a multicentric analysis from India noted that improper oxygen therapy, prolonged hospitalization, and elevated ferritin levels increase fungal proliferation. A. Veisi *et al.* (2021) reported rhino-orbital mucormycosis cases during steroid therapy, stressing cautious dosage and duration monitoring. Imaging features such as periorbital edema, sinus opacification, and vascular invasion have been characterized in radiologic studies by Veisi *et al.* (2021). Pharmacological interventions using amphotericin B, posaconazole, and isavuconazole remain the backbone of treatment Szarpak, 2021; Zurl, 2021) documented successful isavuconazole salvage therapy following debridement. Despite antifungal efficacy, nephrotoxicity and high treatment costs limit accessibility, particularly in rural India Sittig (2021; Ranjbar, 2021). Recent WHO and Indian Council of Medical Research (ICMR) advisories stress rational corticosteroid use, glucose monitoring, and awareness campaigns to reduce CAM incidence Moorthy, (2021). This literature demonstrates that India's CAM epidemic reflects a convergence of biological, therapeutic, and systemic factors requiring integrated public-health strategies.

Pathophysiology and Risk Factors

Mucormycosis develops when fungal spores are inhaled or deposited on mucosal surfaces and germinate under favorable conditions such as hyperglycemia, metabolic acidosis, and immunosuppression Ranjbar, (2021). COVID-19 induces cytokine imbalance and lymphopenia, further impairing host defense mechanisms Lamontagne, (2020). Uncontrolled diabetes increases serum glucose and free iron levels, creating an ideal environment for *Mucorales* proliferation. Prescott and Rice (2020). Corticosteroids—though effective in mitigating COVID-19 cytokine storms suppress neutrophil function and elevate blood glucose, facilitating infection Lamontagne, (2020). Other contributors include prolonged ICU stays, use of non-sterile oxygen humidifiers, and broad-spectrum antibiotics disrupting microbiota Prescott and Rice (2020).

Diagnosis and Clinical Presentation

Clinical symptoms depend on infection site and include facial swelling, nasal obstruction, orbital pain, headache, and black necrotic lesions Ibrahim (2007). Imaging (CT/MRI) reveals sinus opacification and vascular invasion, while histopathology confirms broad, aseptate hyphae with right-angle branching Ibrahim (2007). Early diagnosis is vital; delayed presentation often leads to rhino-orbital-cerebral dissemination, vision loss, or death Prescott and Rice (2020) and Lamontagne (2020).

Treatment and Management

The gold-standard treatment involves a combination of surgical debridement and systemic antifungal therapy. Liposomal amphotericin B (5–10 mg/kg/day) remains first-line but is expensive and nephrotoxic Sterne (2020) and Miller (2021). Alternatives such as posaconazole and isavuconazole serve as salvage or maintenance therapy A. Ibrahim (2007). Combination antifungal regimens, aggressive glycemic control, and correction of metabolic acidosis enhance prognosis Sterne (2020). Prompt discontinuation of steroids and immunosuppressants is advised once infection is suspected. Prescott and Rice (2020)

Public Health Impact in India

India bears the highest global burden of mucormycosis, driven by its large diabetic population and widespread corticosteroid misuse during the pandemic Sterne (2020). The ICMR and Ministry of Health categorized mucormycosis as a notifiable disease in 2021, mandating hospital reporting Prescott and Rice (2020). Awareness among healthcare workers, sterilization of medical devices, and standardized treatment protocols remain crucial. Limited access to liposomal amphotericin B and inadequate diagnostic infrastructure hinder timely intervention Mazzai (2022) and Tlayjeh (2020). Targeted community education, rational drug policies, and fungal surveillance systems are essential to prevent future outbreaks Prescott and Rice (2020) and Park *et al*., (2021).

CONCLUSION

Post–COVID-19 mucormycosis exemplifies the intersection of viral infection, host comorbidities, and therapeutic side effects. The epidemic in India underscores the urgent need for multidisciplinary management, rational corticosteroid prescribing, and better glycemic monitoring. Future research should focus on developing cost-effective antifungal formulations, molecular diagnostic tools, and predictive risk models for early detection. Strengthening hospital infection-control measures and patient education can significantly reduce morbidity and mortality associated with CAM.

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CONFLICT OF INTERESTS

The authors declare no conflict of interest

ETHICS APPROVAL

Not applicable

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AI TOOL DECLARATION

The authors declares that no AI and related tools are used to write the scientific content of this manuscript.

DATA AVAILABILITY

Data will be available on request

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