Published by
Saidu Medical College

OPEN ACCESS

ISSN (P): 1819-4583
ISSN (E): 3007-9470

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Citation:
Khan S, Ilyas M, Arif M, Khan N. Mucormycosis in Diabetic Patients: Clinical Spectrum, Management Strategies, and Treatment Outcomes at a Tertiary Care Center. *J Saidu Med Coll.* 2026;16(1):101–107.

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Funding:
The authors received no external funding for this study.

Conflicts of Interests:
The authors have declared that no competing interests exist.

Data Sharing Statement:
The data that support the findings of this study are available on request from the corresponding author. The data is not publicly available due to privacy or ethical restrictions.

Received: September 11, 2024
1st Revision: October 01, 2025
2nd Revision: November 08, 2025
3rd Revision: December 10, 2025
Accepted: December 13, 2025

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Original Article

Mucormycosis in Diabetic Patients: Clinical Spectrum, Management Strategies, and Treatment Outcomes at a Tertiary Care Center

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https://doi.org/10.52206/jsmc.2026.16.1.1062

Abstract

Background: Mucormycosis is a rare but aggressive opportunistic fungal infection that predominantly affects immunocompromised individuals, particularly patients with diabetes mellitus. Poor glycemic control creates a favorable environment for fungal proliferation, leading to rapid disease progression and high mortality. The rising incidence of mucormycosis among diabetic patients highlights the need for a detailed evaluation of its clinical presentation, management strategies, and outcomes.

Objective: To assess the clinical features, diagnostic approaches, management strategies, and treatment outcomes of mucormycosis among diabetic patients presenting to the Department of ENT, Hayatabad Medical Complex, Peshawar.

Methodology: A retrospective observational cohort study was conducted involving 250 diabetic patients diagnosed with mucormycosis between June 2023 and June 2024. Data were collected from medical records, including demographic characteristics, clinical presentation, diagnostic modalities, treatment strategies, and outcomes. A prospective follow-up of six months was performed to evaluate recovery and mortality. Statistical analysis was carried out using SPSS version 25.0, with significance set at $p < 0.05$.

Results: The rhino-orbital-cerebral form was the most common clinical presentation, affecting 72% of patients. Pulmonary, cutaneous, and disseminated forms were less frequent. Complete recovery was observed in 40%, partial recovery in 36%, while 24% of patients died. Uncontrolled diabetes showed a statistically significant association with increased disease severity and mortality.

Conclusion: Mucormycosis represents a serious and often fatal complication among diabetic patients, particularly those with poor glycemic control. Early diagnosis, aggressive antifungal therapy, timely surgical intervention, and stringent diabetes management are critical to improving patient outcomes. These findings provide valuable insight for optimizing clinical management strategies in resource-limited settings.

Keywords: Diabetes Mellitus, Glycemic Control, Mucormycosis, Rhino-Orbital-Cerebral, Treatment Outcomes.

Introduction

Mucormycosis is a rare but life-threatening opportunistic fungal infection caused by fungi belonging to the order Mucorales. It predominantly affects immunocompromised individuals, with diabetes mellitus particularly uncontrolled diabetes and diabetic ketoacidosis being the most significant predisposing factor [1,2]. The term "black fungus" is commonly used due to the characteristic necrotic tissue destruction associated with vascular invasion and thrombosis. Elevated blood glucose levels, impaired neutrophil function, and an acidic environment collectively facilitate rapid fungal growth in diabetic patients [3,4].

Clinically, mucormycosis manifests in several forms, including rhino-orbital-cerebral, pulmonary, gastrointestinal, cutaneous, and disseminated disease, depending on the route of fungal entry and host immune status [5,6]. Among diabetic patients, the rhino-orbital-cerebral form is the most frequently encountered and is associated with rapid progression, extensive tissue destruction, and high mortality if not promptly treated [7,8]. Early diagnosis is challenging because initial symptoms often mimic other bacterial or fungal infections, leading to diagnostic delays and poor outcomes [9,10].

The COVID-19 pandemic has further intensified concerns regarding mucormycosis, particularly in South Asia. Numerous studies have reported a surge in COVID-19–associated mucormycosis (CAM), especially among diabetic patients exposed to corticosteroids and prolonged hospitalization [11–13]. Although the present study does not specifically evaluate COVID-19 as a risk factor, the overlap between diabetes, immune dysregulation, and opportunistic fungal infections remains clinically relevant and warrants continued investigation.

Pakistan bears a substantial burden of diabetes mellitus, placing a large segment of the population at increased risk for mucormycosis. Despite this, local data on the clinical characteristics and outcomes of mucormycosis in diabetic patients remain scarce, with most available literature limited to case reports or small case series [14]. Larger, systematically conducted studies are needed to better understand disease patterns, optimize management strategies, and improve patient outcomes in this setting.

Therefore, the present study was conducted at the Department of ENT, Hayatabad Medical Complex, Peshawar, to evaluate the clinical spectrum, diagnostic approaches, treatment strategies, and outcomes of mucormycosis in diabetic patients over a one-year period. By analyzing data from 250 patients, this study aims to contribute robust local evidence and support informed clinical decision-making in a population with high diabetes prevalence and limited healthcare resources [15].

Methodology

Study Design

This study employed a retrospective observational cohort design to evaluate the clinical features, management strategies, and outcomes of mucormycosis among diabetic patients. Medical records of eligible patients were reviewed retrospectively to document baseline characteristics, disease presentation, diagnostic approaches, treatment modalities, and immediate outcomes. In addition, a prospective follow-up period of six months after completion of treatment was incorporated to assess recovery status and mortality, allowing a more comprehensive evaluation of patient outcomes.

Ethics

Ethical approval for the study was obtained from the Ethical and Research Committee of Hayatabad Medical Complex, Peshawar. The study was conducted in accordance with the principles of the Declaration of Helsinki and local ethical guidelines for biomedical research involving human participants. Patient confidentiality was strictly maintained by anonymizing data during extraction and analysis. As the study involved retrospective record review, informed consent was obtained where applicable through hospital protocols, and access to medical records was restricted to authorized research personnel only.

Setting

The study was conducted at the Department of ENT, MTI–Hayatabad Medical Complex, Peshawar, a tertiary-care referral center serving a diverse population from urban and rural regions of Khyber Pakhtunkhwa. The study period extended from June 2023 to June 2024, during which all diagnosed cases of mucormycosis in diabetic patients were evaluated. Follow-up assessments continued for six months after treatment completion to document clinical outcomes.

Participants

A total of 250 diabetic patients diagnosed with mucormycosis were included. Eligible participants were adults aged 18 years or older with a confirmed diagnosis of mucormycosis based on clinical evaluation, radiological findings, and histopathological confirmation, and a documented history of type 1 or type 2 diabetes mellitus. Patients without diabetes, those with incomplete medical records, individuals younger than 18 years, or patients

immunocompromised due to causes other than diabetes (such as HIV infection or malignancy-related chemotherapy) were excluded.

Variables
The primary variables included clinical presentation of mucormycosis (rhino-orbital-cerebral, pulmonary, cutaneous, or disseminated forms), treatment modality (medical, surgical, or combined), and clinical outcome (complete recovery, partial recovery, or death). Secondary variables comprised demographic characteristics (age and sex), type of diabetes, glycemic control status, presence of diabetic ketoacidosis, diagnostic modality used, and antifungal regimen administered.

Data Sources/Measurement
Data were extracted retrospectively from hospital medical records using a standardized data collection proforma. Diagnostic confirmation of mucormycosis was based on a combination of clinical findings, imaging studies (CT or MRI), and histopathological evidence of Mucorales fungi. Glycemic control was assessed using fasting blood glucose (FBS) levels and HbA1c values recorded during hospitalization. Treatment details included timing and extent of surgical debridement and antifungal therapy, primarily amphotericin B, with posaconazole used when indicated.

Bias
To minimize information bias, data extraction was performed using predefined variables and uniform criteria. Selection bias was reduced by including all consecutive eligible cases diagnosed during the study period. However, as with all retrospective studies, the possibility of residual confounding and documentation bias could not be completely eliminated. Multivariate statistical analysis was therefore employed to adjust for potential confounders such as age, sex, and glycemic control.

Study Size
The study included 250 patients, a sample size considered adequate to detect meaningful associations between diabetes control, clinical presentation, treatment strategies, and outcomes. The sample size was consistent with similar cohort studies evaluating mucormycosis in diabetic populations and provided sufficient statistical power for subgroup analyses.

Quantitative Variables
Continuous variables, such as age and laboratory values, were treated as quantitative variables and summarized using means and standard deviations. Glycemic control was categorized based on HbA1c levels, with values above 7.0% indicating uncontrolled diabetes. Outcome variables were analyzed as categorical measures representing recovery status or mortality.

Statistical Methods
Data were analyzed using SPSS version 25.0. Descriptive statistics were used to summarize demographic and clinical characteristics. Categorical variables were expressed as frequencies and percentages, while continuous variables were presented as mean ± standard deviation. Associations between clinical outcomes and explanatory variables were assessed using the Chi-square test for categorical data and the Student's t-test for continuous variables. Multivariate regression analysis was performed to adjust for potential confounders. A p-value < 0.05 was considered statistically significant, and 95% confidence intervals were reported where appropriate.

Results

Participants
A total of 250 diabetic patients diagnosed with mucormycosis were included in the final analysis. All patients met the predefined eligibility criteria and had complete clinical and outcome data available for review. The cohort consisted of both male and female patients with either type 1 or type 2 diabetes mellitus, representing a broad adult age range. All participants were followed for up to six months after completion of treatment to assess clinical outcomes, including recovery status and mortality.

Descriptive Data
The mean age of the study population was 56.7 years, indicating that mucormycosis predominantly affected middle-aged to older adults. Males constituted the majority of the cohort (150 patients), while 100 patients were female. Regarding diabetes type, 180 patients had type 2 diabetes mellitus, whereas 70 patients had type 1 diabetes (Table 1). Glycemic control assessment revealed that 200 patients had uncontrolled diabetes, defined by elevated fasting blood glucose levels and/or HbA1c values above recommended thresholds, while only 50 patients had controlled diabetes. These findings underscore the predominance of poor glycemic control among patients presenting with mucormycosis.

Clinically, the rhino-orbital-cerebral form was the most frequent presentation, observed in 72% of cases. Pulmonary mucormycosis accounted for 16%, cutaneous involvement for 8%, and disseminated disease for 4% of patients (Figure 1, Table 02). This distribution reflects the typical predilection

of mucormycosis for the sino-orbital and cranial regions in diabetic individuals.

Outcome Data

Treatment outcomes varied across the cohort. Complete recovery was achieved in 100 patients (40%), characterized by resolution of clinical symptoms and radiological improvement. Partial recovery was observed in 90 patients (36%), where symptoms improved but residual disease or functional deficits persisted on follow-up (Table 03, Figure 02). Despite aggressive management, 60 patients (24%) succumbed to the disease, highlighting the high mortality associated with mucormycosis in diabetic populations. Mortality was more frequently observed among patients with extensive disease and poor glycemic control.

Main Results

Statistical analysis demonstrated a significant association between uncontrolled diabetes and adverse outcomes, including increased mortality ($p < 0.05$). Patients with poor glycemic control were more likely to present with severe forms of mucormycosis and had worse treatment outcomes compared to those with controlled diabetes. Additionally, the type of clinical presentation showed a significant relationship with outcomes, with rhino-orbital-cerebral and disseminated forms associated with higher morbidity and mortality. These findings emphasize that glycemic control and early disease detection are critical determinants of survival in diabetic patients with mucormycosis.

Table 1: Demographic and Clinical Characteristics of Mucormycosis Patients (N=250).

Variables	Frequency
Mean Age	56.7
Male	150
Female	100
Type 1 Diabetes	70
Type 2 Diabetes	180
Uncontrolled Diabetes	200
Controlled Diabetes	50

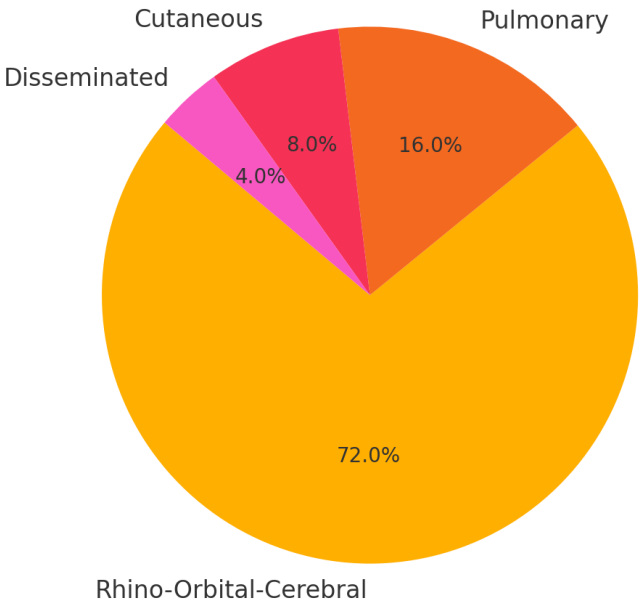


Figure 1: Distribution of Clinical Presentations in Mucormycosis Patients.

Table 2: Distribution of Clinical Presentations.

Variables	Frequency
Rhino-Orbital-Cerebral	180
Pulmonary	40
Cutaneous	20
Disseminated	10

Table 3: Treatment Outcomes of Mucormycosis Patients.

Outcome	Frequency
Complete Recovery	100
Partial Recovery	90
Death	60

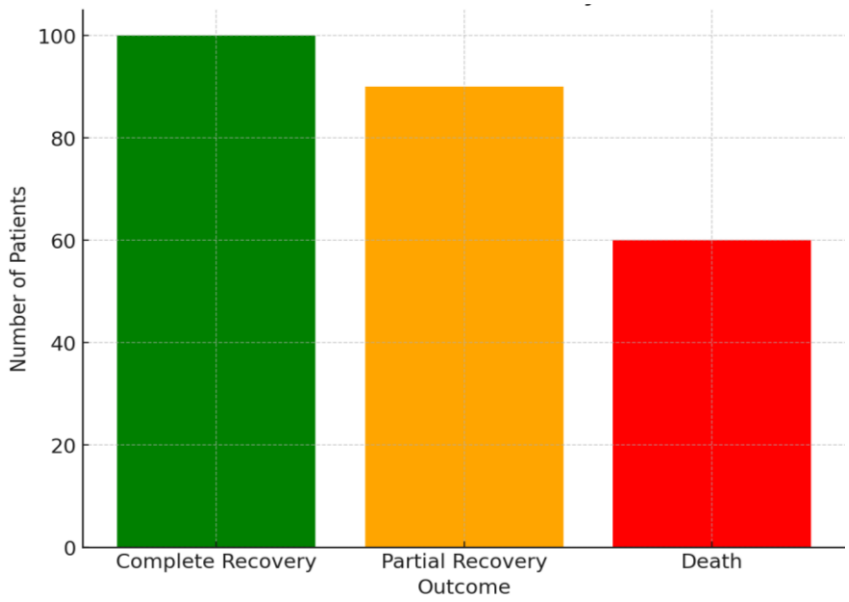


Figure 2: Treatment Outcomes of Mucormycosis Patients

Discussion

Mucormycosis has emerged as a devastating opportunistic fungal infection, particularly among individuals with diabetes mellitus, and continues to pose a significant challenge in low- and middle-income countries. The present study provides one of the largest single-center cohort analyses from Pakistan, offering valuable insights into the clinical spectrum, management strategies, and outcomes of mucormycosis in diabetic patients. By analyzing 250 confirmed cases over a one-year period, this study contributes important regional data to a field largely dominated by reports from neighboring countries and high-income settings.

The findings demonstrate that the rhino-orbital-cerebral form of mucormycosis was the most common presentation, affecting 72% of patients. This observation aligns with existing literature, which consistently reports rhino-orbital-cerebral involvement as the predominant form in diabetic populations [5,7,15]. The anatomical proximity of the paranasal sinuses to the orbit and brain, combined with impaired host immunity and hyperglycemia, facilitates rapid fungal invasion and angioinvasion, leading to extensive tissue necrosis and life-threatening complications [3,4]. Similar prevalence patterns have been reported in studies from India and Iran, suggesting shared environmental exposures and metabolic risk profiles across South Asia [5,15].

Treatment outcomes in the current study revealed that 40% of patients achieved complete recovery, while 36% showed partial recovery, and 24% died. These outcomes are comparable to international reports, where mortality rates for mucormycosis range from 20% to over 50%, depending on disease extent, comorbidities, and timeliness of intervention [3,9]. The relatively high survival rate observed in this cohort may be attributed to the combined use of early surgical debridement and systemic antifungal therapy, a strategy that has been widely endorsed as the cornerstone of effective mucormycosis management [4,8].

A key finding of this study is the significant association between uncontrolled diabetes and increased mortality, reinforcing the critical role of glycemic control in disease progression and outcomes. Hyperglycemia impairs neutrophil chemotaxis and phagocytosis, promotes iron availability, and creates an acidic environment that favors fungal proliferation [3,12]. Similar associations between poor glycemic control and adverse outcomes have been reported in large systematic reviews and meta-analyses, particularly in the context of COVID-19–associated mucormycosis [11–15]. Although the present study did not specifically stratify patients based on COVID-19 status, the overlap between diabetes, immune dysregulation, and opportunistic fungal infections remains clinically significant. The findings also underscore the importance of early diagnosis, as delayed recognition continues to be a major contributor to poor outcomes. Nonspecific early symptoms often mimic sinusitis or orbital cellulitis, leading to diagnostic delays that allow disease progression [9,10]. In resource-limited settings such as Pakistan, limited access to advanced diagnostic modalities further compounds this challenge, emphasizing the need for heightened clinical suspicion and early referral.

This study adds meaningful local evidence to the global understanding of mucormycosis in diabetic patients. It highlights the need for multidisciplinary management, integrating endocrinology, infectious disease, ENT surgery, radiology, and critical care, to improve survival outcomes in this high-risk population.

Limitations

Despite its strengths, this study has several limitations. First, the single-center design limits the generalizability of the findings to other regions of Pakistan. Second, the retrospective nature of data collection may have introduced information bias due to incomplete or inconsistent medical records. Third, potential confounding factors such as prior corticosteroid use, COVID-19 status, and socioeconomic determinants could not be comprehensively assessed. Additionally, long-term functional outcomes beyond the six-month follow-up period were not evaluated. Future multicenter, prospective studies are needed to overcome these limitations and provide a more comprehensive understanding of mucormycosis epidemiology and outcomes in diabetic populations.

Conclusion

This study demonstrates that mucormycosis remains a severe and potentially fatal complication among diabetic patients, particularly those with uncontrolled glycemia. The predominance of the rhino-orbital-cerebral form and the substantial mortality rate underscore the urgency of early diagnosis and aggressive management. Prompt initiation of antifungal therapy, timely surgical intervention, and strict glycemic control are critical determinants of survival. The findings emphasize the need for improved awareness, early referral pathways, and tailored management strategies to reduce morbidity and mortality associated with mucormycosis in diabetic patients, especially within the Pakistani healthcare context.

Authors' Contributions:

All authors meet the ICMJE criteria for authorship.

Author 1: Substantial contribution to conception and design, drafting the manuscript, final approval, agreed to be accountable for all the work.
Author 2: Substantial contribution to conception and design, data acquisition, drafting the manuscript, final approval, agreed to be accountable for all the work.
Author 3: Analysis and interpretation of data, drafting the manuscript, final approval, agreed to be accountable for all the work.
Author 4: Analysis and interpretation of data, critical revision, final approval, agreed to be accountable for all the work.

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