



# **Mucormycosis and It's Prevalence in the Patients of COVID-19**

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## **Authors' contributions**

*This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.*

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## **ABSTRACT**

The world today is going through a series of uncalled events, that has hindered the balance of livelihood in the current population. This is due to the emergence of the COVID-19 but along with that, the COVID-19 has accompanied several other rare and extremely fatal fungal infections under its shadows, such as the Mucormycosis. Mucormycosis is caused particularly in the immunocompromised hosts by the saprophytic fungi of Mucorales species. This infection leads to several clinical conditions, under the influence of the COVID-19 Associated Mucormycosis, commonly being the conditions such as the rhino-cerebral disease. This condition occurs mainly in the patients with diabetes mellitus. Several other respiratory, gastrointestinal and cutaneous contaminations also occur during this condition. COVID-9 accompanied with diabetes mellitus can be extremely life threatening. Now, there are several predisposing factor to the Mucormycosis which could accompany the severity of the conditions such as the Ketoacidosis in the patients with diabetes mellitus, patients on the immunosuppressive therapies, previous pulmonary infections and other nosocomial contaminations. There are no specific biomarkers available to diagnose Mucormycosis; Histopathological examination of the biopsied tissue and imaging of the involved area are most important in diagnosis. Mucormycosis being an angioinvasive fungus, usually is present in the surroundings with wet surfaces and dead and decaying vegetable matter. The term black fungus is used as in for the dematiaceous fungi, which are an entirely different group. Since

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the COVID-19 pandemic is on its massive widespread in the country, the new variant being more infectious, people are more tend to some other complications of the COVID-19 contamination such as that of the secondary fungal infections causing high mortality rates.

*Keywords: COVID-19; Mucormycosis; fungal infections; black fungus; histopathology; biomarkers; clinicopathological findings; diabetes mellitus; rhino-cerebral disease.*

## 1. INTRODUCTION

The cases of both Mucormycosis and Aspergillosis are scarce in the population, even though they are capturing and lethal infections. The specific agents that cause this infection mainly being the *Aspergillus fumigatus* and the *Rhizopus arrhizus* species. Henceforth, the rate of lethality being over 40% [1].

The *Rhizopus arrhizus* infections, if noted, chiefly include the syndromes of the respiratory tract, the cutaneous and the gastrointestinal tract. The rhino-orbital-cerebral is also included in this, *Rhizopus arrhizus* infections. In the severely immunocompromised patients, these extreme angio-invasive infections may spread and this then leads to the high fatality rates in the population [2].

The sars-CoV-2 infection, so drastically changing itself, has several complications occurring in itself. A few of these complications that are recognised and accepted are the Invasive Aspergillosis and Mucormycosis infections. The patients that are under the category of the severely affected by the Covid-19 are under the treatment for the same in the Intensive Care Units (ICU), the infections are mostly seen in these extremely ill patients.

The patients of invasive pulmonary aspergillosis, an infection caused during the same extreme conditions, has been seen to have decreased in number in the cases of these COVID -19 patients that have been admitted in the ICUs, the stats being close around 35% when noted. Turns out these cases of pulmonary aspergillosis have been kept on a closely linked with the corticosteroid therapy that has been provided prior to the infection [3].

## 2. BLACK FUNGUS “A CRISIS IN THE PANDEMIC”

The current crisis of COVID-19 has already affected the world to a far extent but under all of this current pandemic there is a recent cataclysm evolving all over. This has been noted to be

spreading at vast degrees throughout the country and causing unprecedented deaths, where as the rapidly evolving and changing strains of the corona virus has already made the situation out of grasp [4].

The Indian population being unique in its socio-economic, healthcare and genetic status, develops a certain high levelled incubator for the sustaining of the “black fungus” infection to achieve a powerful grasp. According to health minister, there are around 2000 outlet cases of Mucormycosis in the state of Maharashtra itself. A term defined to as the “Perfect storm”, basically the classic combination Diabetes mellitus, the COVID-19 and immunosuppression, has shown an enormous upward manoeuvre in the country all over. Hence it can be noticeably said that within the global pandemic exists an underlying epidemic, that is the “black fungus” (Mucormycosis) [5].

## 3. THE RESULTS SO FAR

In an overall estimation, till date, all around the world for Mucormycosis in patients with Corona infestation, out of the 101 cases registered, around 82 cases and 19 cases were from India and the rest of the world, respectively. Apparently in males, the Mucormycosis cases are mor prevalent as compared to the females. In the males, in people who were currently infected with COVID-19 and the ones who had recovered the cases shown were 60% and 40% respectively. Around 76.3% of the cases were recorded that were formulated for the treatment of COVID-19 through the corticosteroid therapy [6].

## 4. A CASE STUDY OF THE MUCORMYCOSIS COINFECTION

A study was made to do a further investigation for the COVID-19 and the Mucormycosis infestations during the same. Here, nine proclamations were made, apart from a certain case, rest all the other cases were found to have occurred in men in the age range 23-85 years of age. If we consider the different clinical forms of

the Mucormycosis, the uppermost type was the rhino-orbital. Another clinical form considered after the rhino-orbital type is the pulmonary type, which is then noted as a chief clinical form for the Mucormycosis coinfection [7].

Every year, the number of cases reported are just one of either gastrointestinal or the rhino-orbital conditions. Included in the main subject to risk factors were ketoacidosis, use of the broad-spectrum antibiotics and the glucocorticoids, diabetes mellitus. In addition to this, further main factors susceptible to high risks for the Mucormycosis infection in the respiratory tract were reported namely the ischemic cardiac myopathy, high blood pressure and end stage kidney diseases and other renal disorders [8].

The diagnosis for the mycosis was built mainly on the basis of the histopathological investigations and culture analysis. Different methods used for determining the clinical picture, in one of the cases, PCR and sequencing were used for detection whereas in the other two cases, the methods of magnetic resonance imaging (MRI) were appraised for the detection and the finding out of the pathogen. Several pathogens were detected, their etiological order in which they have been noted are in the following descending orders: *Mucor* spp., *Rhizopus* microspores, *Rhizopus* spp., and *Lichteimia* spp. In not less than 35 percent of the cases, the fungal species was not identified. Nevertheless provided with so many options of several antifungal curative methods, such as amphotericin B and Isavuconazole, just the half of the patients showed any improvement in their clinical statistics. Hence the rate of lethality was considered to be around 50% [9].

Culture is an essential technique for diagnosing mucormycosis since it may help identify the genus and species that caused the infection as well as evaluate antifungal susceptibility. Culture has a poor sensitivity, since it might be mistakenly negative 50% of the time. When incubated at 25–55°C, Mucorales grows fast on most fungal culture medium, such as Sabouraud agar and potato dextrose agar, and this may be used to differentiate it from the closely related *Aspergillus*. The hyphae are fibrous, resembling cotton candy. Light colour, generally yellow on the back of the plate, and colourful sporulating colonies ranging from white to black are further distinguishing characteristics. The presence of rhizoids, stolons, and columella on lactophenol cotton blue mounts can be used to distinguish between fungus species [10].

A biopsy of the lesion can be collected and submitted for histological investigation, which will reveal Mucorales-like fungal hyphae. Fungal infiltration of blood vessels, vasculitis, thrombosis, tissue infarction, bleeding, perineural invasion, and a large neutrophilic infiltrate are all seen on histology. Hematoxylin and eosin staining can sometimes reveal merely the cell wall, with no internal structures, or highly degenerate hyphae. The fungus can then be seen using special stains as Grocott-methenamine silver and periodic acid-schiff stain [11].

The fungus may be identified with high sensitivity using molecular approaches such as PCR-based techniques. The fungus can be detected early in the infection using a quantitative multiplex polymerase chain reaction-based 18S rRNA test. Internal transcribed spacer sequencing for molecular identification is strongly suggested as a future method [12].

Nasal endoscopy and noncontrast CT of the paranasal sinuses are the first-line investigations for rhino-orbito-cerebral mucor, although gadolinium-enhanced MRI is preferable for identifying intra-orbital or intracranial extension. Mucormycosis is strongly indicated by sinus opacification, localised bone erosions, extrasinus spread, the black turbinate sign (cavernous sinus involvement), and intracranial extension [13].

Nodules or masses, halo sign, inverted halo sign (region of ground-glass opacity encircled by a ring of consolidation), consolidation, central necrosis, air-crescent sign, and blockage of pulmonary arteries on CT angiography are all signs of pulmonary mucormycosis [14].

Early suspicion, quick diagnosis, and elimination of the predisposing conditions are essential for effective care of mucormycosis. The combination of surgical debridement of the lesion and early antifungal medication improves the clinical result. The rhino-oculo-cerebral type necessitates extensive surgical debridement of necrotic regions and surrounding tiny normal portions, with several procedures necessary in most instances. In a large majority of situations, this can result in an improvement [15].

The treatment arsenal available includes amphotericin B, posaconazole, and isavuconazole, with amphotericin B being the most effective. Amphotericin B polyene liposomal is recommended over amphotericin B

deoxycholate because it has less nephrotoxicity and intolerance. Amphotericin works against fungi by attaching to sterols, particularly ergosterol, which gives fungal cells structure and stiffness. It's best to give 5–10 mg/kg/day for at least 3 weeks and then titrate with PCR [16].

However, the time can be adjusted based on the individual's reaction, and triazole maintenance can also be explored. 10 mg/kg dosages and prolonged treatments are required for CNS and disseminated types. The total cumulative dosage for the whole therapy should be 2.5–3 g in the ideal case. Amphotericin B deoxycholate is a feasible alternative since it is less expensive and more readily available. During treatment, serum potassium and kidney parameters must be constantly monitored [17].

For individuals who are intolerant to amphotericin B, the triazoles posaconazole and isavuconazole are considered second-line and salvage treatment. Posaconazole has just been accessible in IV and oral forms, which may impact therapy in the future given that it is now only used in syrup form. It might also be used as a preventative measure. Posaconazole is usually taken in doses of 200 mg every 6 hours or 400 mg every 12 hours [18].

Isavuconazole is still in its early phases of development and is thus not routinely prescribed, however its high bioavailability, linear pharmacokinetics, and broad-spectrum properties may make it more popular in the future. The current protocol is a loading dosage of 200 mg every 8 hours for two days, followed by 200 mg once a day [19].

Mucormycosis has not been shown to be treatable with itraconazole, terbinafine, voriconazole, or caspofungin. Other therapeutic possibilities include hyperbaric oxygen, iron chelation with nondesferrioxamine chelators, and granulocyte-macrophage colony-stimulating factor [20].

## 5. INCIDENCES OF MUCORMYCOSIS

There had been recent reports of spreading out of the incidence of Mucormycosis from India that indicate these incidences occurring. The cases of Mucormycosis occurring more prominently in the COVID-19 patients. Mucormycosis can be fatal, if the fungus species that causing the same penetrates into the central nervous system. These fungal species are basically filamentous

fungi or, belong to the order Mucorales. The COVID-19 associated Mucormycosis (CAM) has been on its maximum height ever since its invasion into the country. Currently Rhizopus arrhizus has proven to be the determiner and common etiological agent for the same. In India a few cases had also shown the prevalence of etiological agents such as the Mucor irregularis, Rhizopus microscopus, Saksenaea erythrospora and the Rhizopus homothallicus. Patients that are undergoing an immunosuppressive therapy and the patients with diabetes or the immunocompromised convalescents, the Mucormycosis infections are more customary. There had been many surveys regarding the prevalence of the cases of Mucormycosis in India [21].

Among all these surveys the use of corticosteroids and its significance in the covid patients along with the fatality of the Covid Associated Mucormycosis (CAM) were of main concern, each being 76.3% and 30.7% respectively. It is still uncertain whether the cases of Mucormycosis are worldwide or just localised to certain areas. A clear record has to be created of all such cases reported till now in order to carry forward the research regarding this matter. Although, when we consider India, there has been a certain conclusion that, the risk factors and the extreme lengths of widespread presence of CAM in India is mainly due to the faultily managed diabetes patients and the very long use of the steroids for the treatment of the COVID-19 patients [22].

As if now, in several patients, all over the country and the world, suffering from COVID-19 associated pneumonia, the use of steroids for the effective treatment of the same has been very common. Now due to this prominent use of certain steroids, the secondary fungal contaminations are being observed on an elevated scale of high risks. This can further lead to fatality and a substantial increase in the death rates. Talking about death rates, the fact that India has been beholding a steep rise to the COVID-19 incidences and has maintained its position of the increasing fatality rates is a matter of concern. It has been very difficult to manage the COVID-19 pandemic chiefly because of the different critical aspects and the risk factors, mainly, the aspects of pneumonia and pulmonary thrombosis. The reason why there is an augmented or expanding increase in the COVID-19 cases is because of lack of awareness in the population for the corona prevention [23].

COVID 19 has been a particularly challenging pandemic to contain, because to the high rates of pneumonia and thrombosis. Since the beginning of the COVID pandemic in December 2019, secondary infections of both bacterial and fungal type have been detected. Following natural catastrophes such as the tsunami in India in 2004 or the tornado in Missouri in 2011, mucormycosis has been reported to rise in prevalence. Fungal infection was the leading cause of mortality in individuals with severe acute respiratory syndrome during the SARS-CoV pandemic in 2003, accounting for 25%–73.7 percent of deaths [24].

The exponential surge during the coronavirus epidemic, on the other hand, was unprecedented. Patients were mostly treated with home isolation and, in a few cases, steroids during the initial wave. However, many patients in the second wave required greater doses of steroids for longer periods of time, as well as high-flow oxygen for extended periods of time owing to hypoxia. Mechanical ventilation was necessary for a far larger number of patients [25].

Diabetes as a common comorbidity, pre-existing alveolo-interstitial lung disease, increased use of steroids and other immunosuppressives, covid pneumonia, increased chances of nosocomial infection, prolonged ICU stays, hospitalisation, mechanical ventilation, and immune alterations caused by Covid-19 infection have all contributed to the rise in mucormycosis cases. The main risk is certainly diabetes, which is a predisposing factor for not just fungal infections but also more serious covid infections. Diabetes that is uncontrolled raises the risk by a factor of ten. Another issue with diabetes is renal involvement [26-32].

## 6. CONCLUSION

In conclusion, we believe that analysing and reanalysing the data collected from the patients of COVID-19, the type of infection, the risk factors involved and the methods of treating these fungal infections come in handy during the COVID-19 treatment. The prevalence of Covid Associated Mucormycosis is expectedly high in India. In an overall survey conducted, it has been that the mortality rate of the cases outlined from India were no less than 36.5% which when noted, was comparatively less than the cases extensively reported at the global level which is

around 70%. This might be probably due to the preponderance of the rhino-cerebellar Mucormycosis. There had been several surveys conducted so far, out of these the most multiresolution scrutiny or examination, it has been that pulmonary or the promulgated Mucormycosis cases and the registered cases to the Intensive Care Units are interrelated with an elevated the levels of fatality, whereas the intermixed medical therapy into a combination has boosted up the rate as well as the chances of survival. It has been noticed that the reason why there is a rarity in the cases of pulmonary or propagated Mucormycosis cases from India is because there are not any registered cases of a lot many COVID-19 Associated Cases either because they were not diagnosed or because they were not reported sooner. Further with help of a lot many researched articles coming to a conclusion that there is an elevated and an extremely sizeable and meaningfully significant rise in the cases of the COVID-19 Associated Mucormycosis. Hence, Mucormycosis solely has been an effective cause of high risks in the patients of the COVID -19. Since it has been known that the Mucormycosis is a very probable threat to the life for the people who are already suffering from the COVID-19, hence, it must require ensured care and proper facilities for the management of such patients belonging in the Intensive Care Unit facilities. The management of these patients also requires large-scale surgical processes and also at the very most a dragged out and a very protracted medical therapy with the amphotericin-B. Now, even though we know that there is a certain correlation between the COVID-19 and Mucormycosis being a risk factor for the same, still we do not have a lot many research studies and records proving the same and showing this existing correlation in the patients. In order to have a proper record regarding this fungal infestation, Mucormycosis, during the COVID-19 the government needs to maintain the proper records for the patients that are registered in ICU facilities and all the samples collected needs to arranged sequentially, followed by a histopathological laboratory diagnosis for the identification of the fungus associated and a CT scan. Apart from that, this routine has to be followed by providing the patients with proper antifungal medications and the competence of a surgical expert alongside the operative facilities. A managed and equitable distribution of the resources for the COVID-19 support has to be managed in order to decrease the fatality rates of the patients.

## CONSENT

It is not applicable.

## ETHICAL APPROVAL

It is not applicable.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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