

Review Article*Open Access, Volume 2***Mask induced mucormycosis: An unexplored possibility?****Akriti Sharma^{1*}; Sandhya Khunger²; Rohit Bhardwaj³; Arun Kumar¹; Vikas Kakkar¹; Manuswita Roy⁴**¹Department of Otorhinolaryngology, SGT Medical College, Hospital & Research Institute, Village Budhera, Gurugram, Haryana 122505, India.²Department of Microbiology, Faculty of Allied Health Sciences, SGT University, Village Budhera, Gurugram, Haryana 122505, India.³Department of Otorhinolaryngology, Army College of Medical Sciences and Base Hospital, Delhi Cantt-10, India.⁴Department of ENT, Swami Rama Himalayan University, Swami Ram Nagar, Jolly Grant, Dehradun, Uttarakhand, India.***Corresponding Author: Akriti Sharma**Department of Otorhinolaryngology, SGT Medical
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Introduction

Mucormycosis is a rare angioinvasive fungal infection attributed to filamentous fungi called mucormycetes [1]. According to reports published during the period between December 2019 and early April 2021. Approximately 71% of the cases of mucormycosis in COVID infected individuals across the globe have been reported from India [2]. A sudden surge in cases of mucormycosis during the ongoing covid-19 pandemic has been witnessed recently and several factors have been proposed to explain this unexpected outbreak. Studies suggest that severe COVID-19 patients become immunocompromised and therefore are more susceptible to fungal infection [3]. Diabetes Mellitus has been recognized as one of the important risk factors for mucormycosis [4]. A recent study identified the associated risk factors, clinical features, and outcomes of COVID-19-associated mucormycosis [2]. The over-zealous use of steroids in treatment

of covid-19 patients has also been identified as one of the potential reasons for a rise in cases of mucormycosis during the ongoing pandemic. Hence the triad of immunocompromised host, diabetes mellitus and steroids has been established as the main reason behind the sudden rise in cases of Mucormycosis. Recently other factors such as the rise in serum ferritin levels, long term stays in the intensive care units, increased intake of zinc and antibiotics have also been documented [5-7].

In our opinion, at a time when clinicians and scientists are trying to analyse all the possible reasons behind covid-19 associated mucormycosis, importance of physical factors such as personal hygiene including hand hygiene and mask hygiene cannot be undermined. While the world health organisation has constantly emphasized the role of hand hygiene during the pandemic and much has been said about the topic to make people aware, mask hygiene is a subject that needs to be re-

searched upon and taken seriously particularly with respect to mucormycosis. Hence it becomes imperative to evaluate the role of environmental factors in India and their association with mask hygiene.

Masks have been seen to provide adequate protection during the entire course of the pandemic. Wearing masks regularly has resulted in minimizing the transmission of virus-laden aerosols from a COVID patient there by reducing the inhalation of these particles by people surrounding the infected individual [8,9]. While slowly and steadily, more and more people became aware about the importance of wearing a mask, little did they know about mask hygiene.

This article has been written with the objective to analyse the role of mask hygiene and associate it with pre-existent environmental factors and other important considerations which could possibly have contributed to mucormycosis during the covid-19 pandemic. For an in depth scientific understanding of this subject, detailed literature search regarding fungi and ideal conditions for their proliferation was done to understand if masks could prove to be a potential source of infection. Roles of factors such as dust, moisture, temperature and environment in India along with others such as air velocity on the surfaces of masks as well as the properties of materials used in manufacturing masks have been explored in detail.

Role of temperature and environment and their correlation with mask hygiene

Mucorales release sporangiospores that are easily aerosolised and are considered to be a major mode of transmission. Studies also reveal that fungal levels are seen highest in summer and autumn and lowest in winter and spring [10]. Fungi can grow over temperature that could range from 5 degrees to 39 degrees [11]. It is reported that at a temperature between 34-36°C the metabolic rate of fungi is expected to peak, thereby creating a conducive environment for fungal proliferation. Incidentally, a sudden surge in cases of mucormycosis was witnessed in months when the average temperature in India was less than 46°C [12]. Outbreaks of rhinocerebral or pulmonary zygomycosis have been linked to inhalation of sporangiospores in an environment of dust [10]. Dampness and moisture are known to proliferate the growth of fungi [13,14]. While these environmental factors have been persistent in India since a long time, wearing of masks continuously and for long periods became a new normal with the onset of the covid-19 pandemic.

Improper and unhygienic practices such as reusing contaminated masks, as well as lack of knowledge and awareness about mask hygiene could have possibly paved the way to mucormycosis during the pandemic.

Role of accumulated dust on masks

Dust including microorganisms and other plant and animal waste provides nutrients in sufficient quantity for fungal growth [15]. Hence it is natural that fungal growth will be much more in surfaces with dust as compared to those without dust [16,17]. It is observed that settled particulate matter (present in soil and dust) modifies the water retaining properties of a surface,

making it wet and providing a favourable environment for fungi to flourish [18]. Dust particles have a tendency to absorb water from the surroundings, compete with material surfaces for moisture and retain more water owing to their hygroscopic nature [19]. Hence the accumulation of dust on masks could promote fungal growth particularly when all other pre-requisites such as optimum temperature, humidity, air flow and a favourable material surface are available.

Role of materials used for manufacturing masks

Fungal proliferation is also influenced by factors such as type of materials used for masks and air volume passing over its surface [19].

N95 masks and surgical masks recommended for usage during the covid-19 pandemic, proved to be far more superior as compared to cloth masks. However there was an acute shortage of N95 masks at the onset of the pandemic and they were recommended to be used by the healthcare staff. Moreover the use of cloth masks for the general population was being encouraged by numerous policy makers including WHO. Even when supply of N95 masks was resorted, the unaffordability and unavailability of these in rural areas of India led to rampant usage of cloth masks across the country. Among the different materials used for manufacturing cloth masks, cotton is the most common [20].

All types of materials, be it organic or inorganic, have been found suitable for fungal growth particularly when there are deposits of dust particles on their surface acting as a source of carbon and nitrogen are able to sustain fungal life especially when the materials have dust, dirt or other deposits on their surface which represent sources of carbon and nitrogen [21,22]. Another important factor required for growth on these surfaces is relative humidity. Cloth masks, most commonly made of porous materials like cotton, support fungal growth owing to their property of water adsorption. Porous materials are reported to support fungal growth at a relative humidity of over 80% [23].

Important materials used in manufacturing masks include cotton, nylon, polyester etc. [20]. The repeated and prolonged use of unsterilised and dirty masks, made of porous materials that have a tendency to retain water and allow air movement across its surface, in a tropical country like India could have been instrumental in the sudden outbreak of mucormycosis in India during the covid-19 Pandemic.

Socio-economic status

Another point to take note of is with respect to the socio-economic aspect of individuals using unhygienic masks. It is being reported that opportunistic infections are being seen in individuals with low socio economic status [24]. Rhino-cerebral mucormycosis could possibly result from the lack of knowledge regarding mask hygiene in rural areas of India particularly in people of lower socio-economic background due to the repeated usage of cloth masks most of which could be self manufactured. Moreover poorly ventilated spaces can further promote the growth of fungi. Though several measures of disinfecting both N95 and cloth masks have been explained in detailed studies [20], the awareness on mask sterilisation is still very limited.

Role of air velocity

Studies report that air velocity has a very important role to play in fungal growth. While the concentration of fungal spores increases with an increase in air velocity, their viability is seen to decrease [19]. Masks made of porous materials facilitate the movement of air through their surfaces hence providing a surface ideal for fungal proliferation. It has been reported that repeated use of the same mask increased the microbial contamination on the mask [25].

All factors such as air velocity, moisture, temperature conditions, adequate ventilation, a higher number of inhabitants and their activities, presence of dust, and quality of outdoor air are all seen to have an impact on the microbial contamination of indoor air quality. Hence studies recommend good ventilation and housekeeping practices along with keeping the relative humidity levels low in the indoor environment to limit fungal proliferation [25]. Since fungi present in the indoor environment could accumulate on masks we also recommend following all practices to keep surfaces free of dust and moisture and ensure ventilation of closed spaces.

Conclusion

In India dust, temperature and humidity and a lack of awareness about mask cleanliness could have paved a way for a sudden rise in cases of mucormycosis in addition to other factors such as the triad of diabetes mellitus, immunocompromised host and steroids among many others. Inhalation and exhalation while wearing a mask or that is unwashed or damp may provide all the essential prerequisites including air velocity, a damp cotton or cellulose material, dust and microbes for fungi to thrive on its surface. Although there is limited literature to support the possibility of mask-induced mucormycosis, the role of mask hygiene in prevention of mucormycosis is a subject that could be explored further. In our opinion, detailed studies are required to conclude if there is a definite role of awareness regarding mask hygiene in prevention of mucormycosis in future.

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