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ORIGINAL ARTICLE

Fungal spore count in a tertiary care hospital in Mumbai, India

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Abstract

Fungal spores are present in the environment. Diabetic and immunosuppressed persons are more vulnerable to such infections. Thus, it is a major concern in a hospital setup as appropriate temperature and humidity can lead to fungal growth. The fairly humid and slightly warm climate of Mumbai is ideal for fungal growth. Here is a brief description of how fungal spores were controlled within a tertiary hospital in Mumbai, India with simple but effective methods. The total fungal count in Mumbai was found to be 16.2 CFUs/m³ (1). During the study period, there were two instances where fungal growth was observed, which is as follows: 1) bone marrow transplant (BMT) (Oct-2017 to Jan-2018): Growth of different *Aspergillus spp*. (12–36 CFU/m³) was observed 2) ICU (Oct-2019 to Nov-2019) : Growth of *A. niger* (6–24 CFU/m³) was observed. Corrective actions such as cleaning of the AC ducts, repair of the leakages and filter cleaning were done. Due to the prompt correctional actions, we were able to prevent nosocomial fungal infections from these areas. Even though the hospital is situated by the sea and the outside air has high humidity and high microbial load, effective engineering measures and close monitoring of the areas helped in controlling the spread of fungus within the hospital. Routine periodic checks (weekly in BMT unit and monthly in ICUs) of the air for fungal spores can also help prevent nosocomial infections.

Keywords: *infection control*; *air surveillance*; *nosocomial fungal infections*; *Aspergillus spp*

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Fungal spores are present in the environment. Although frequent exposure to these spores occurs all the time in most healthy individuals, spores are removed by functional innate defence mechanisms like monocyte-derived and resident macrophages (2). But unfortunately, they can cause severe life-threatening infections in immunocompromised patients such as patients with haematological malignancies, solid organ transplants (SOT) and also patients with diabetes. Invasive fungal infection (IFI) caused by filamentous fungi, especially invasive aspergillosis (IA), has become a high-prevalence infection in such patients.

Background

Hospital environment contains many fungal spores, which can cause infection to susceptible hosts. It is not possible to control the fungal spore count in all areas of the hospital. But, in high priority areas such as operation theatres (OT), ICUs and bone marrow transplant (BMT) units, environmental control can be obtained by using High Efficiency Particulate Air (HEPA) filters and air handling units (AHUs). Construction and renovation activities can cause serious dust contamination and disperse large amounts of fungal spores to the environment, and construction activity has been reported to be an independent risk factor for IFIs (3, 4). This study describes the incidence of high fungal spore count observed in two different critical areas of our hospital (BMT and ICU) and actions taken to find out the cause and control the counts.

Methods

According to the hospital policy, weekly air sampling is done from OT, central sterile supplies department (CSSD), in vitro fertilisation unit (IVF) and BMT. Other critical areas like intensive care units (ICU), Cath Lab, Digital Subtraction Angiography (DSA) Lab are sampled monthly for air contaminants. HEPA filters are installed in OT, BMT, CSSD, IVF. For air sampling, portable centrifugal system is used. Two types of air samplers are used in the hospital: Strip air sampler (Dynamicro) and plate air sampler (Heico Air sampler). Air is filtered at a rate of 40 L in 1 min (40 L/min) onto Soyabean Casein Digest Agar. A total volume of 1,000 L air is filtered for air sampling, followed by incubation of plates/strips at 37°C for 1 week to observe fungal growth. The fungal colonies grown

are identified and reported as number of colony forming units (CFU)/mm³.

Results

Air sampling is done routinely in the critical areas of our hospital over all these years. The only instances that we detected as positive fungal growth are described next in this study. As a result of swift corrective actions, we were able to prevent the incidence of hospital acquired fungal infections. Effective environmental control is obtained with the help of good engineering measures and routine periodic environmental checks.

Incidence of fugal growth: Series of events

Bone Marrow Transplant unit (Oct-2017 to Jan-2018)

During October 2017, the air sampling from BMT unit showed growth of *Aspergillus spp*. 12–36 CFU/m³ (*Aspergillus niger, Aspergillus flavus and Aspergillus fumigatus*). Investigations to find out the cause of this increase in fungal spore count was done. Repeat air sampling was done to confirm the earlier growth. Two consecutive air samplings showed positive fungal spore count of 24 and 36 CFU/m³, respectively, in two out of the four isolation rooms. On examination of the BMT unit, seepage was observed in one wall as a result of heavy rains, which was suspected to be the cause for the observed air sampling results. This rain water seepage was promptly repaired and antifungal paints were applied, following which air sampling was repeated. The observed counts were 12 and 24 CFU/m³ of *A. niger* growth. The unit was closed down during this period. Corrective actions were continued during this period-HEPA filters were changed and duct cleaning was done.

Further investigation showed an additional leakage, which was found at the sink in the ante room. This was repaired immediately. On further air sampling, no fungal growth was observed in the isolation rooms. The unit was reopened after three consecutive negative air sampling reports for fungus.

Intensive Care Unit (Oct-2019 to Nov-2019)

Fungal growth was detected during October 2019 in the ICU during routine air sampling. Growth of *A. niger* (6–24 CFU/m³) was observed. Individual cubicle air sampling was done following these results. Two out of 11 cubicles showed positive growth of *A. niger* 6 CFU/m³ each. Both these cubicles were blocked and corrective actions were commenced, which included filter cleaning of the AHU. But the air sampling that was done following this still showed growth of *A. niger.* In this situation, this particular ICU was closed and the patients were transferred to other ICU. On investigation, it was revealed that there was water accumulation above the false ceiling due to condensation.

Intense cleaning of the AHU ducts and filters/cooling coils was done. The entire ICU was thoroughly cleaned, which also included cleaning of the area above the false ceiling of the ICU. Air sampling was repeated after the cleaning procedures. After one and half month repeat three consecutive air sampling reports came negative and the ICU was reopened.

Discussion

An overall increase has been reported in fungal health care-associated infections (HAIs). This is partly due to the growing population of immunocompromised patients and the increased use of invasive medical devices. Among the nosocomial infections caused by moulds, Aspergillus spp. causes most of the infections: 76% among Haematopoietic stem cell transplant (HSCT) recipients and 81% among SOT recipients. Outbreaks of nosocomial aspergillosis in severely immunocompromised patients such as allogeneic HSCT recipients and neutropenic patients with hematologic malignancies has been reported from different parts of the world. Although several outbreaks of environmental airborne fungal infection within hospital settings have been reported, most of the cases of IA are sporadic (5).

The risk factors associated with increased fungal spore count in a health care facility are mainly construction, renovation, remodelling and repairs. Improperly functioning ventilation systems, window air conditioners, air exhaust contamination, false ceilings and damp wood building materials are implicated as environmental vehicles for fungal spores, mainly Aspergillus spp. The presence of fungal spores is reduced by designing the heating, ventilation, and air conditioning (HVAC) systems in health-care facilities so as to:

1) maintain the indoor air humidity and temperature at comfortable levels for staff, patients, and visitors
2) control odours
3) remove the contaminated air
4) facilitate air-handling requirements so as to protect susceptible individuals (staff and patients) from airborne health-care associated pathogens
5) minimize the risk for transmission of airborne pathogenic microbes from infected patients.

Decreased performance of healthcare facility HVAC systems, improper installation, filter inefficiencies and poor maintenance can contribute to the spread of health-care associated airborne infections (6). Engineering controls are also important to contain or prevent the spread of airborne contaminants. These include local exhaust ventilation (i.e. source control), general ventilation, and air cleaning.

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Infection control precautions for construction and renovation activity at our hospital at highest risk areas(including ICU, BMT)

The infection control guidelines for construction and renovation activity at our hospital has been adapted from the document 'Infection Control Risk Assessment Matrix of Precautions for Construction and Renovation' by the Carpenters International Training fund (7). The scenario described above involves type of work that generates a moderate to high level of dust, which includes removal of floor coverings, ceiling tiles and case work, minor duct work or electrical work above ceilings, etc. The infection control precautions taken during these activities are described in Table 1.

Random and undirected (routine) air sampling is not recommended, but, targeted air surveillance is recommended by Centers for Disease Control and Prevention (CDC). The specific indications for this being investigation of an outbreak, for research purpose, after reconstruction/ newly constructed buildings and for short term evaluation of a change in infection control practice. However, periodic air sampling from critical areas will help to maintain good air quality standards in these areas.

Even though no strict numerical guidelines are available for *Aspergillus* counts, the national guidelines of the United Kingdom for prevention of nosocomial aspergillosis recommendation for interpretation of the fungal spore burden state is that the fungal spores in air should be <5 CFU/mm³ in the absence of air filtration and <1 CFU/mm³ in HEPA filtered air (8).

The Spanish SEIMC guidelines for prevention of invasive mould diseases recommends that unfiltered air must contain no more than 5 conidia/m³, although other experts accept between 10 and 25 CFU/m³. However, air filtered through HEPA filters with an efficiency >95% and with ≥12 air changes per hour must have a count <0.1 CFU/m³ (9).

The earlier publications on nosocomial fungal outbreaks reports that a wide range of airborne fungal levels (1–10 CFU/mm³ to 200 CFU/mm³) associated with construction, renovation and demolition has caused infection to patients (3). There are studies that mention even <1 CFU/m³ of spore burden could be associated with an *Aspergillus* outbreak among immunocompromised patients (2).

Factors in controlling the spread of fungal spores at our hospital are as follows

- Temperature should not exceed 18–23° ± 2
- Humidity should be (≤60%)
- Regular AHU filter and AC duct cleaning
- Different sizes of filters used for filtration of circulating air in hospital
- All HEPA filters are monitored 6 monthly for particulate count
- Number of air changes (OT, BMT, CSSD, IVF >20/h; Wards and other areas>6/h) (5).
- Use of antifungal paints in the hospital (in BMT, ICUs and OT)
- Regular checks for any leakage or seepage issues
- Construction activities in the hospital are undertaken with Infection Control approval and appropriate measures to control fungal spore dissemination, which includes proper cohorting and sealing of the area
- Due to the periodic air sampling from critical areas, we were able to detect the high spore counts and thus prevent IFIs.

Conclusion

Effective engineering measures and close monitoring of the areas helped in controlling fungal spores within the hospital. Routine periodic checks of the air for fungal

Table 1. Infection control precautions taken during renovation activities at highest risk areas

During construction project	Upon completion of project
1) Isolate HVAC system in area where work is done to prevent contamination of duct system.	1) Do not remove barriers from work until completed project is inspected by the infection control committee (ICC).
2) Complete all critical barriers, that is, sheetrock, plywood, plastic, to seal area from non- work area before construction begins.	2) Remove barrier materials carefully to minimize spreading of dirt and debris associated with construction.
3) Maintain negative pressure within the work site throughout the construction period to prevent the spread of airborne contaminants.	3) Contain construction waste before transport in tightly covered containers.
4) Seal holes, pipes, conduits and punctures.	4) Covers transport receptacles or carts. Tape covering unless solid lid.
5) Construct anteroom and ask all personnel to pass through this room.	5) Work area should be vacuum cleaned
6) All personnel exiting work sites are required to wear shoe covers. Shoe covers must be changed each time the worker exits the work area.	6) Wet mop area with cleanser/ disinfectant
	7) Upon completion, restore HVAC system where work was performed.

spores can also help prevent nosocomial infections and prompt infection prevention and control measures are to be strictly observed for preventing such infections.

Conflict of interest

The authors declare no conflict of interest.

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