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Preventing invasive fungal infection during hospital building works

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Abstract

Hospital building works increase the risk of invasive fungal infections. Nosocomial outbreaks have been reported. A pre-emptive strategy for planned building works is paramount. The roles of HEPA filtration, air-sampling and modulation of 'routine' antifungal prophylaxis practice are discussed in the context of pre-emptive planning and outbreak management.

Hospital building works is an established, independent risk factor for invasive fungal infections (IFI).[1,2] Over the last three decades, numerous nosocomial IFI outbreaks have been reported, most frequently in the haematology-oncology setting,[3] but also in intensive care,[4–6] lung transplant[7] and renal units.[8,9] These outbreaks have been associated with both minor and major building works. A temporal relationship often exists between the institution's reported rise in IFI rates and the carrying out of demolition and construction work. Several investigators have employed genotyping (of isolates) to provide evidence for a single-point nosocomial outbreak.[3,10] *Aspergillus* is perhaps the most notorious construction-related pathogen but other fungi including *Scedosporium* spp. have also been linked to building works.[1,11]

A small, retrospective, case–control study revealed that IFI 'cases' confirmed at autopsy were more likely to have been hospitalized during hospital construction work ($P < 0.02$).[10] A separate clinico-epidemiological study found that rates of IFI rose from 1.2% pre-construction to 7.9% when construction was at its peak ($P < 0.001$).[12]

Pre-emptive planning for building works

Hospital building works is an ever-constant phenomenon in modern-day health care.[3,13] A variety of infectious sources exists in health-care facilities during construction and renovation activities. Thus, when such activities are being planned, health-care personnel and other professionals must consider potential sources of highly concentrated microorganisms that may cause nosocomial infections.

A pre-emptive approach to planned building works is paramount.[13] Readers should refer to guidelines published by the Centers for Disease Control (CDC)[2,14,15] and local authorities[16,17] for explicit recommendations. These expert groups emphasize the need for early and sustained coordinated planning between infection control, building, engineering and other ancillary teams, and the need to clearly define the responsibilities of each supporting service.[18,19] In an era of rapidly advancing technologies, health-care facilities are obliged to keep abreast of current best practice and budget appropriately for any

anticipated costs related to environmental sealing, air sampling and air filtration.[18] The implementation of any recommendations should, of course, be carefully supervised.[18]

A risk profile should be carried out during the pre-planning stage as part of a robust risk management programme. At a minimum, the risk profile should (i) identify the location of high-risk patients within the site, (ii) identify ventilation system types and their potential impact; determine air monitoring requirements, methodology and frequency and (iii) take air samples to establish baseline values and identify possible contaminants and their locations (e.g. ceiling dust, service shafts, sprayed-on fire retardants and bird droppings).[17]

It is beyond the scope of the current review to detail all technical, construction-related precautions. These can be found elsewhere.[13–17] Herein, we review the three most controversial issues related to the prevention of IFIs during hospital building works.

High-efficiency particulate air (HEPA) filters

Despite early evidence that HEPA filter systems effectively reduced spore counts,[20] nosocomial outbreaks and individual cases of IA have still occurred in settings where these systems are in place.[19] While HEPA-filtered rooms are recommended by the Centres for Disease Control (CDC) for high-risk patients,[2,14] a recent meta-analysis of 16 trials showed that HEPA filtration did not significantly improve mortality rates among patients with haematological malignancies and severe neutropenia in randomized or non-randomised controlled trials (RCT) (RR 0.86, 95% CI 0.65–1.14; RR 0.87, 95% CI 0.6–1.25, respectively).[21] This may relate, in part, to the fact that HEPA filters are complex to install and maintain; improper or poor installation and/or maintenance may not adequately control fungal spores leading to outbreaks of aspergillosis.[13,19]

Air sampling

Hospital units managing immunosuppressed patients must adhere strictly to air quality standards. Air sampling detects viable airborne fungal spores. It may form part of a site's risk management programme before and during construction. Cumulative data are used to establish indoor and outdoor background levels of filamentous fungi for a particular site, enabling risk profiles for particular locations in and around the hospital to be established.

While air sampling may provide valuable information about ventilation performance, especially before patients occupy a 'special ventilation' (SPV) area,[13] the role of routine air sampling is controversial.[14,15] There are many different types of air samplers available but no standardized protocols to guide their application (e.g. collection time, airflow rate) or analysis, which impedes data comparison.[14,22] Some experts suggest shifting the emphasis towards providing real-time data instead to confirm that air in SPV areas is clean and appropriately pressurized.

Peaks in fungal spore concentrations detected by air sampling can indicate a change in ecology but there is no proven direct correlation between fungal spore concentrations, colonization and rates of IFI. Institutions that have adopted routine surveillance air sampling may use observed peaks in fungal spore concentrations to prompt timely reviews of the maintenance and cleaning of airflow systems.

Antifungal prophylaxis in the setting of building works

No controlled studies of antifungal prophylaxis have been performed in the specific setting of building works. However, the threshold for antifungal prophylaxis should be lower in the presence of ongoing building works. The relative ease of administration and safety of the newer oral antifungal agents make this feasible.

Clinicians are accustomed to stratifying patients to low-intermediate, and high-risk groups.[23] The practice of 'routine antifungal prophylaxis' for high-risk patient groups varies between medical units and institutions. Currently, most units provide routine antifungal prophylaxis to all patients with severe graft versus host disease (GVHD) and allogeneic stem cell transplants. However, it has become increasingly common for clinicians to also prescribe antifungal prophylaxis to neutropenic patients with acute leukaemia and myelodysplastic syndromes (as supported by Cornely *et al.*, 2007).[24] Institutions that only routinely administer antifungal prophylaxis to patients traditionally considered 'high risk' may consider lowering their threshold to include patients at 'intermediate-high' risk if building works are imminent.[25]

Outbreak management

In an ideal world, pre-planning for imminent hospital building works would obviate the need for outbreak management. In the setting of an established outbreak, the importance of transparency, accountability and open-channel communication between all clinical units, infection control, engineering, cleaning and ancillary staff cannot be overstated. Environmental measures for control of nosocomial IFI include relocation of high-risk patients to a distant location, masking, wet-cleaning, reducing unnecessary thoroughfare and sealing of patient care areas with impermeable barriers.[2,14,15]

Most occurrences of invasive aspergillosis (IA) are sporadic; any clustering of cases should prompt an outbreak investigation. The incubation period of IA is unknown, making it particularly difficult to determine if an infection was acquired within or outside the hospital setting.[26] It should be noted that the finding of unrelated fungal strains within a patient cluster does not negate the possibility of a nosocomial outbreak, as most IFIs are not clonal.[3]

During investigations of 24 outbreaks of IA with air-sampling data, the concentration of airborne fungi in patient care areas ranged from 0 to 100 spore/m^3.[3] Notably, concentrations of *Aspergillus* spp. below 1 colony-forming unit/m^3 are sufficient to cause infection in high-risk patients.[3] We must emphasize that without baseline data, single air sampling measurements are impossible to interpret[26] – the concentration and dissemination of fungal spores varies constantly with climate change and movement, thus, single peaks may be missed.[3]

Installing HEPA filters during a nosocomial outbreak may help to control the outbreak, though a range of environmental measures is usually employed concomitantly, making it impossible to attribute the observed effect to HEPA filters alone.[6,27,28] A number of outbreak reports suggest that commencing antifungal prophylaxis during an outbreak may also be of benefit.[9,11,27,29–31] However, most of these reports came from outbreaks that occurred before 1995 when antifungal prophylaxis for high-risk patient groups was not yet routine. We recommend lowering the threshold for antifungal prophylaxis – using a broader-spectrum antifungal agent or including patient groups other than those at 'high' risk – in the presence of ongoing building works.

Implications for research

Further research is required to aid the prevention of nosocomial infection during hospital building works. The development of protocols to guide surveillance air sampling (including the need to routinely collect baseline data), along with the validation of available air samplers, would be useful. Prospective studies of air sampling are also required. An audit of HEPA filters and IFI rates may help to highlight the importance of regular cleaning and maintenance. The practice of reporting fungal outbreaks should also be encouraged. Moreover, a national surveillance database of fungi cultures, IFI rates and antifungal practice during building works would be beneficial to raise awareness and help guide future practice.

Conclusion

The diagnosis and treatment of IFI is increasingly complex, particularly in the haematology–oncology setting. These guidelines will require modification over the next few years to keep apace of new developments and the introduction of newer antifungal agents. Future updates to these guidelines will be posted at: http://www.asid.net.au/guidelinesandpublications/. The Australian Society for Infectious Diseases (ASID) website will also contain information about any related activities. Interested individuals are invited to provide feedback on these guidelines and/or register to participate in a national audit so that we can formally evaluate how these guidelines are being implemented. You can do this by visiting http://www.asid.net.au/contactus/ and choosing 'Antifungal guidelines' from the drop-down menu.

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