

Refurbishment works in a hospital during normal operation

Umbauarbeiten in einem Krankenhaus während des regulären Betriebes

Abstract

Background: Construction and renovation work in hospitals pose risks of fungal airborne infections for immunosuppressed patients. If possible, reconstruction work will be postponed to periods without patient treatment. However, in many situations urgent damage demands immediate refurbishment works before the transferring of patients to other wards or closure of wards is possible. Reported here are infection control related measures and implemented procedures after two incidents of water damage which occurred on a surgical ward and an intensive care unit at the University hospital of Essen.

Methods: Between January and April 2009 and between September and October 2009, respectively, concentration of air-borne particles and number of viable fungi were measured at two surgical wards and one ICU. Preventive Infection Control Measures included erection of protective walls and HEPA filtration of air from the renovation area.

Results: During the renovation work on the surgical ward concentrations of moulds and particles $\geq 5 \mu\text{m}$ were significantly higher on the left side of the renovation area than on the right side ($p=0.036$ and $p<0.001$). Concentrations of particles $\geq 1 \mu\text{m}$ and particles $\geq 5 \mu\text{m}$ on both sides of the renovation area were significantly increased when compared with the control ward on the same floor but not when compared with the control ward on the other floor. Particles of all size were significantly elevated on the ICU during the renovation work. *Aspergillus fumigatus* could neither be cultured of the air of cardiac surgery intensive care unit nor of the intermediate care unit (control ward). During renovation works there was no nosocomial mould infection of patients treated on the two wards.

Conclusion: Provided that the renovation area is tightly insulated from the areas of patient care on a ward, closure does not seem to be necessary during renovation works because variation of airborne fungi is similar to that of outdoor or control air. However a multidisciplinary team should be established. This team should perform risk assessment and determine necessary protective measures before starting any construction, renovation or maintenance work in health care settings.

Keywords: construction work, renovation, hospital, fungal infection, dust, surgical ward, ICU

Zusammenfassung

Hintergrund: Bau- und Renovierungsarbeiten in Krankenhäusern können Infektionsrisiken insbesondere durch Pilze für immunsupprimierte Patienten mit sich bringen. Wenn möglich, werden Umbauarbeiten in Zeiten gelegt, in denen keine Patienten behandelt werden. Häufig jedoch erfordern Schäden dringendes Handeln, ohne dass Patienten verlegt oder Stationen stillgelegt werden können. Nachfolgend wird über Schutzmaßnahmen und begleitende Messungen bei zwei Wasserschäden auf einer chirurgischen und einer Intensiv-Station des Universitätsklinikums Essen berichtet.

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Methoden: Zwischen Januar und April 2009 sowie zwischen September und Oktober 2009 wurden jeweils die Luft-Konzentrationen von Partikeln und lebensfähigen Pilzen auf einer chirurgischen Station sowie auf einer Intensivstation gemessen. Die angewandten Schutzmaßnahmen umfassten Abschottungen und die HEPA-Filterung der im Renovierungsbereich abgeführten Luft.

Ergebnisse: Während der Sanierungsarbeiten auf der chirurgischen Station waren die Luftkonzentrationen der Schimmelpilze und Partikel $\geq 5 \mu\text{m}$ signifikant höher auf der linken Seite als auf der rechten Seite der Renovierungsfläche ($p=0,036$ und $p<0,001$). Die Konzentrationen der Partikel $\geq 1 \mu\text{m}$ und $\geq 5 \mu\text{m}$ auf beiden Seiten des Renovierungsbereichs waren signifikant höher als jene auf der Vergleichsstation auf der gleichen Etage, aber nicht im Vergleich zu einer Vergleichsstation auf einer anderen Etage. Partikel aller Größenklassen waren während der Renovierung auf der Intensivstation signifikant erhöht. *Aspergillus fumigatus* konnte weder aus der Luft der Herz-Thorax-Intensivstation noch aus jener der Intermediate-Care-Station kultiviert werden. Während der Renovierungsarbeiten traten keine nosokomialen Infektionen durch Pilze auf beiden Stationen auf.

Schlussfolgerung: Vorausgesetzt, dass der eigentliche Renovierungsbereich gut von den anderen Bereichen der Patientenversorgung auf einer Station abgetrennt ist, scheint ein Schließen der Station nicht unbedingt notwendig, da auch in der Außen- und Vergleichsluft die Konzentration der Pilze in der Luft erheblich schwankt. Allerdings sollte die Maßnahme von einem multidisziplinären Team begleitet werden. Dieses Team sollte vor Beginn der Arbeiten eine Risikoanalyse durchführen und die Schutzmaßnahmen festlegen.

Schlüsselwörter: Bauarbeiten, Renovierung, Krankenhaus, Pilzinfektion, Staub, chirurgische Station, Intensivstation

Introduction

Building and renovation measures cannot only cause significant contamination of dust but can also liberate great amounts of fungal spores and therefore can pose the risk of invasive aspergillosis in severely immunocompromised patients with e.g. bone marrow or organ transplants and acute leukaemias [1], [2]. In acute care hospitals ward closure or the transferring of patients is often impossible in cases of sudden events. The aim of this study was to monitor the load of particulate matter and fungal spores after two incidents of considerable damage caused by water which occurred in University hospital of Essen and which had to be managed during ward activity. In January 2009 water damage occurred in the bathroom of a surgical ward of University hospital of Essen. The wall of the bathroom and the floors of two adjacent patient rooms and the adjacent ward's corridor were wet and had to be scraped. The corridor of the ward had direct access to the surgical intensive care unit. Dust protecting walls were installed insulating the ward from the affected rooms and the affected part of the corridor (Figure 1 and Figure 2). Negative pressure was maintained in affected rooms during building activity. Exhaust air was conducted outside through a sealed hole in the window (Figure 3). Exhaust air was HEPA filtered.

In September 2009 the second incident happened in one room of the cardiac surgical intensive care ward. The procedure was the same as described above.



Figure 1: Dust protection – view from surgical ward



Figure 2: Dust protection – view from renovation area



Figure 3: Exhaust air

Methods

Between January and April 2009 and between September and October 2009 respectively we measured concentrations of particles ≥ 0.3 , ≥ 0.5 , ≥ 1 and ≥ 5 μm and fungi in the air of affected wards. Measuring devices were placed 1 m to 1.50 m above ground level and 1 m distant from the doors of dust protecting walls. On the surgical ward measurements were performed on both sides of the corridor, the left side from the renovation area directed towards the intensive care unit, the right side directed towards the stairway. Control measurements were performed on two surgical wards and on an intermediate

care ward respectively. Air supply of the cardiac surgery intensive care unit and intermediate care unit was HEPA filtered. The control wards were located in the same buildings but on different floors. Particles were counted by APC plus (Biotest). Fungal counts were determined as colony forming units (cfu). 2X 50 litres of air were collected by MAS-100 (Merck) on sabouraud agar, which were incubated aerobically at 25 °C for 5 days. *Aspergillus fumigatus* was identified by colony morphology, microscopy and growth at 42 °C. The measuring head of MAS-100 was autoclaved between consecutive working days. All instruments were calibrated regularly according to manufacturer's instructions. We analysed data of the hospital documentation system for diagnosed or suspected aspergillus infections of patients from both intensive care wards. Statistical analysis was performed on a personal computer using the Statistical Package for Social Science (SPSS). Results were significant if $p < 0.05$.

Results

Results of the measurements during the renovation work on the surgical ward are shown in Table 1 and Table 2 and results of measurements during the renovation on the cardiac surgical intensive care unit are shown in Table 3 and Table 4. During the renovation work on the surgical ward concentrations of moulds and particles ≥ 5 μm were significantly higher on the left side of the renovation area than on the right side ($p = 0.036$ and $p < 0.001$). Concentrations of particles ≥ 1 μm and particles ≥ 5 μm on both sides of the renovation area were significantly increased when compared with the control ward on the same floor but not when compared with the control ward on the other floor. On the contrary, concentrations of moulds and particles > 0.3 μm , > 0.5 μm and > 1 μm were significantly higher on the control ward on the other floor than on the ward with renovation work going on. During the renovation work on cardiac surgical intensive care unit concentrations of particles of all sizes were significantly elevated. There was no difference in fungal concentration between the cardiac surgical intensive care ward and intermediate care ward. *Aspergillus fumigatus* could neither be cultured of the air of the cardiac surgical intensive care unit nor of the intermediate care unit. During renovation works no nosocomial mould infection of patients treated on the two wards occurred.

Table 1: Number of particles $\geq 0.3 \mu$, particles $\geq 0.5 \mu$, particles $\geq 1 \mu$ and particles $\geq 5 \mu$ (minimum, maximum and median) in the air of the surgical ward during renovation works and in the air of two control wards

	Number of days of measurements	$\geq 0.3 \mu$ $\times 10^6/m^3$			$\geq 0.5 \mu$ $\times 10^5/m^3$			$\geq 1 \mu$ $\times 10^4/m^3$			$\geq 5 \mu$ $\times 10^3/m^3$		
		Min.	Max.	Median	Min.	Max.	Median	Min.	Max.	Median	Min.	Max.	Median
Surgical ward	31	0.9	8.1	3.2	1.5	21.1	4.9	5.1	72.2	12.3	1.5	17.6	4.8
Side towards intensive care unit													
Surgical ward	31	1.0	7.2	3.3	1.1	16.5	4.5	3.4	95.8	12.9	1.0	72.6	2.8
Side towards stairway													
Control ward on the same floor	31	1.1	9.9	2.8	1.4	28.0	3.4	3.1	86.3	9.6	0.8	12.0	2.4
Control ward on another floor	26	1.8	13.7	6.0	2.4	38.0	6.9	6.4	194.4	14.3	0.8	175.9	3.4

Table 2: Number of cfu/m³ of moulds (minimum, maximum and median) and number of measurements with A. fumigatus and maximal concentration (cfu/m³) of A. fumigatus in the air of the surgical ward during renovation works and in the air of two control wards.

	Number of days of measurements	Moulds CFU/m ³			Number of measurements with A. fumigatus	Maximum of A. fumigates CFU/m ³
		Min.	Max.	Median		
Surgical ward	28	<10	Confluent growth	75	7	40
Side towards intensive care unit						
Surgical ward	28	<10	Confluent growth	30	6	20
Side towards stairway						
Control ward on the same floor	28	<10	Confluent growth	50	4	50
Control ward on another floor	24	<10	Confluent growth	70	9	50

Table 3: Number of particles $\geq 0.3 \mu$, particles $\geq 0.5 \mu$, particles $\geq 1 \mu$ and particles $\geq 5 \mu$ (minimum, maximum and median) in the air of the cardiac surgery intensive care ward during renovation works and in the air of the intermediate care ward

	Number of days of measurements	$\geq 0.3 \mu$ $\times 10^6/m^3$			$\geq 0.5 \mu$ $\times 10^5/m^3$			$\geq 1 \mu$ $\times 10^4/m^3$			$\geq 5 \mu$ $\times 10^3/m^3$		
		Min.	Max.	Median	Min.	Max.	Median	Min.	Max.	Median	Min.	Max.	Median
Cardiac surgery intensive care ward	14	0.1	3.2	0.2	0.4	15.6	0.7	1.8	86.6	3.0	1.9	144.4	3.6
Cardiac surgery intermediate care ward	14	0.0	7.3	0.1	0.1	22.2	0.4	0.4	81.0	1.6	0.2	61.1	2.3

Table 4: Number of cfu/m³ of moulds (minimum, maximum and median) and number of measurements with A. fumigatus and maximal concentration (cfu/m³) of A. fumigatus in the air of the cardiac surgery intensive care ward during renovation works and in the air of the intermediate care ward

	Number of days of measurements	Moulds CFU/m ³			Number of measurements with A. fumigatus	Maximum of A. fumigates CFU/m ³
		Min.	Max.	Median		
Cardiac surgery intensive care ward	12	<10	360	<10	0	
Cardiac surgery intermediate care ward	14	<10	<10	<10	0	

Discussion

Results of our study are inconsistent. Concentrations of moulds and particles $\geq 5 \mu\text{m}$ at two different measuring points which were only few meters apart from each other on the affected surgical ward were significantly different. These differences cannot be explained. At the left side where the concentrations of particles were elevated doors were kept closed whereas rubbish was carried outside on the right side. Similar to Cooper et al. [3] who could not find any statistically significant difference in the levels of viable fungi during construction work performed with protective measures we could not find any increase of concentrations of particles and moulds on the surgical ward compared to both control wards [4]. On the contrary particle and fungal concentrations on the control ward on another floor of the building were significantly increased. It is unlikely that this increase was caused by dust blown through the opened windows because exhausted air of the renovated rooms passed through a HEPA filter. Indoor concentration of particles and moulds is not only supposed to be influenced by outdoor air but also by indoor activity [4]. On the control ward there were a lot of movements of patients and members of staff which might have influenced particle and fungal concentrations in the air. The mean concentrations of moulds on the surgical ward as well as on both control wards were higher than those measured by Ortiz et al. [5] in the air of hospital rooms in a hospital in Spain but were less than those found by Kolk et al. [6] in outdoor air in Germany. Peak concentrations of moulds during well partitioned construction and renovation works were found to be in the same range as concentrations of outdoor air in Germany [6], [7].

The cardiac surgery intensive care unit and intermediate care unit are provided with Hepa filters. Although particle concentrations were increased on surgery intensive care unit during renovation work there was no rise of fungal concentration and no *Aspergillus fumigatus* was cultured from the air. Reports about the effect of HEPA-filtration on aerial fungal concentration during renovation or construction works are different. Mahieu et al. [8] found a significant reduction of *Aspergillus* spores during renovation works by use of mobile air filtration system. Cornet et al. [9] reported an increase of aerial fungal concentration on a ward adjacent to hospital renovation despite being protected with HEPA filtration. An explanation could be renovation and construction works producing different amounts of dust and thus liberating different numbers of fungal spores. But Goodly et al. [10] concluded from measurements performed during one year that spore concentrations could not be predicted from the nature of building work. Another explanation of different results could be different volumes of air sampled. The volume of air sampled by Mahieu et al. [8] as well as by us was 100 liters whereas that of Cornet et al. [9] was 250 liters. Thio et al. [11] compared the ability of different air samplers to detect *Aspergillus* spores.

They found that the detection rates of *Aspergillus* spores were dependent of sampled volume.

Provided that the renovation area is tightly insulated from the areas of patient care on a ward, closure does not seem to be necessary during renovation works because variation of airborne fungi is similar to that of outdoor and control air. Similar conclusions were drawn by Rautiala et al. [12] who measured aerial fungi adjacent to construction zones which were placed under negative pressure and which were isolated with a plastic barrier. However a multidisciplinary team should be established. This team should perform risk assessment and determine necessary protective measures before starting any construction, renovation or maintenance work in health care settings. Patients with increased risk of invasive aspergillosis should be identified and should be moved to other wards far away from construction and renovation areas and use of mobile HEPA filters should be considered. Nosocomial outbreaks of fungal infections have been caused by aerial concentrations as low as 1.1 cfu/m^3 *Aspergillus fumigatus* and no minimal infective dose of aerial viable fungal spores can be given [13]. Protective effect of treating the air by a HEPA filter has been shown [14], [15]. There are controversial indications as to whether fungal spore concentration should be measured during construction or renovation works in healthcare settings [16], [17] but air pressure gradients are advised to be regularly verified in artificially ventilated areas [18].

Conclusions

Provided that the renovation area is tightly insulated from the areas of patient care on a ward, closure does not seem to be necessary during urgent renovation works because variation of airborne fungi is similar to that of outdoor air or air in control wards. However a multidisciplinary team should be established. This team should perform risk assessment and determine necessary protective measures before starting any construction, renovation or maintenance work in health care settings.

Notes

Conflicts of interest

The authors declare that they have no competing interests.

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