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Short Report

Airborne *Aspergillus fumigatus* contamination in an intensive care unit: Detection, management and control

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ABSTRACT

Intensive care unit (ICU) patients are often extremely vulnerable to suffer an infection from airborne pathogens. Therefore, an environmental outbreak of *Aspergillus fumigatus* in an ICU should be handled in a concise and efficient way. In this short report, we describe an outbreak of *A. fumigatus* in the ICU of a Belgian secondary care hospital. Following initial detection of a humidity problem and airborne *A. fumigatus*, the department of infection prevention took urgent measures for damage control and resolution of the problem. As such a timely resolution has been provided, with assurance of a clean and healthy environment for the critical patients.

Background

Aspergillus species are ubiquitous environmental organisms, however, may act as opportunistic pathogens. *Aspergillus fumigatus* is one of the most important Aspergillus species in the etiology of infections, especially in immunocompromised individuals. A significant number of patients experience life-threatening invasive infections with these opportunistic pathogens mainly through inhalation of the airborne *Aspergillus* conidia [1]. Several studies report poor outcomes for invasive aspergillosis, with mortality rates as high as 90 percent [2,3]. Survival depends upon several host factors such as neutropenia, glucocorticoid treatment and environmental factors [4]. As such, Pelaez et al. described that both quantity and exposure to the conidia are known risk factors for the development of invasive aspergillosis [5]. Most studies agree upon a 10 colony forming units (CFU)/m^3 cut-off bio-aerosol level, related to a low invasive aspergillosis risk [6]. In accordance, Curtis et al. described a mean total *Aspergillus* colony count in a tertiary-care hospital setting of 12.1 CFU/m^3 in indoor samples and 7.3 CFU/m^3 in a critical-care setting (bone marrow transplant patient rooms) [7].

In this report, we describe an environmental outbreak of *A. fumigatus* in an intensive care ward (6 beds) at a secondary care hospital in Belgium (366 beds). The ICU department consists of 6 individually isolated units. The appearance of a humid stain on the roofing material of one of the units in the intensive ward department urged the nurses to consult the hospital's infection prevention team.

Methods

With the discovery of a moisty stain on the roof material in one of the ICU boxes (number 4), initial surface and air sampling was performed by the infection prevention team. ESwab (Copan, Italy) samples were collected from interior elements such as the roofing pains, ventilation vents, walls, etc. These swabs were inoculated on blood agar plates (trypticase soy agar II with 5% sheep blood, BD, USA). Air sampling was performed simultaneously by positioning opened blood agar plates over-night in the different ICU boxes. After proper incubation of all blood agar plates for 24–72 h (aerobic at 35 ± 2 °C with 5% CO_2), identification of the cultivated species at genus and species level was performed by means of microscopy (direct microscopy from cultivated colony, without staining) and MALDI-TOF (matrix assisted laser desorption/ionisation time-of-flight analyzer) [8]. After cultivation of *A. fumigatus* in these preliminary/screening samples a specialised laboratory was consulted to conduct quantitative air and surface sampling, both at the initial detection of the *Aspergillus* outbreak (February 26th '18) and after resolution (March 5th '18). Air sampling was conducted through flow of 1000 L over a Sabouraud agar (glucose with chloramphenicol, BD, USA) (reported as CFU/m^3), with a MAS-100 eco R air sampler (Merck, Germany). The number of CFU/m^3 was calculated using the formula: (CFU/plate × 1000)/volume of air in litres

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Table 1
Results of surface- and air- sampling in the ICU ward and different benchmark departments, before and after restoration, cleaning and decontamination procedures (E + 00 = 10Ô).

	Sample collection	Before (February 26th '18)	After (March 5th '18)
Surface swabs	Roofing panels, walls, etc.	<1.0E + 01 CFU/cm^2	<1.0E + 01 CFU/cm^2
Air samples	ICU box 1	1.8E + 01 CFU/m^3	<1.0E + 00 CFU/m^3
	ICU box 2	2.4E + 01 CFU/m^3	<1.0E + 00 CFU/m^3
	ICU box 3	1.5E + 01 CFU/m^3	<1.0E + 00 CFU/m^3
	ICU box 4	6.4E + 02 CFU/m^3	<1.0E + 00 CFU/m^3
	ICU box 5	1.0E + 02 CFU/m^3	<1.0E + 00 CFU/m^3
	ICU box 6	1.6E + 01 CFU/m^3	<1.0E + 00 CFU/m^3
Benchmarking	Maternity ward	<1.0E + 00 CFU/m^3	/
Benchmarking	Internal medicine ward (504)	1.0E + 01 CFU/m^3	/
Benchmarking	Surgical ward (459)	1.9E + 01 CFU/m^3	/

[9]. Surface swabs were inoculated on the same kind of Sabouraud agar media (reported as CFU/m^2). All 6 ICU boxes were sampled before and after restoration of the roof, additionally air sampling was conducted at randomly selected wards to obtain benchmark data to verify the "general *A. fumigatus* presence" in the hospital (maternity ward, internal medicine ward and surgical ward).

Results

The initial non-quantitative cultivation results from the surface and air samples, collected by a member of the infection prevention team, are not reported. The results of subsequent environmental sampling by the specialised external laboratory are presented in Table 1. Surface swabs from different elements of the ICU boxes did not result in cultivation of *A. fumigatus*. However, air sampling, through a MAS-100 eco R air sampler and subsequent incubation, resulted in *A. fumigatus* CFU counts >1.0E + 01 CFU/m^3 in every ICU box (Table 1). We identified *A. fumigatus* through direct microscopic examination of the colonies (presence of the typical aspergillum with columnar conidial heads and phialides) and MALDI-OF. There was a significant presence of *Aspergillus* at the onset of the outbreak (February 26th '18), in ICU boxes 4 and 5, the air content of 6.4 and 1.0E + 02 CFU/m^3 exceeded the threshold of approximately 10 CFU/m^3 air. Even though, the air content of the other ICU units did not trespass the limit at such numbers, still a meticulous and strict adherence of the airborne CFU is essential in critical care departments. Benchmarking sampling was performed on other general internal and surgical wards and resulted in low non-significant CFU-counts. After restoration, cleaning and decontamination of the different ICU boxes (at March 5th '18), novel air and surface samples were obtained, all below the threshold levels.

Discussion

At the onset of the outbreak, *A. fumigatus* was cultivated from different air samples. In this perspective, dust containing *Aspergillus* spores is difficult to avoid in an indoor setting. Even though HEPA filters present in critical-care wards should prevent airborne *Aspergillus* and limit the number of CFU to an absolute minimum, thermotolerant molds can colonize water-damaged parts of the interior and actively grow and colonize wet materials [10]. Original detection of high Aspergillus CFU count in the moisty roof material led the hospital authorities to encounter an event of "*A. fumigatus* presence which could potentially lead to an outbreak". The results obtained from air sampling (Table 1) show a significant presence of airborne *Aspergillus* in ICU boxes 4 and 5. A 10-year prevalence study described a median CFU count in an ICU department of 26 CFU/m^3, with CFU counts ranging from 18 to 47 CFU/m^3 in other departments [11]. Another report of a one-year surveillance project described somewhat lower *Aspergillus* conidia counts of 12.1 CFU/m^3 in general wards versus 7.3 CFU/m^3 in the bone marrow transplant rooms [7]. In addition to these surveillance reports, an outbreak report of invasive aspergillosis described the potential pathogenicity of high *Aspergillus* conidia counts (>150 CFU/m^3) in an oncology department [12]. In our setting, the high conidia load in two of six ICU boxes, with the potential pathogenicity of small, airborne conidia accessing the lower respiratory tract of ICU-hospitalized patients, the infection prevention team decided to close the intensive care unit on short notice, after counselling with a multidisciplinary team (consisting of clinicians of the ICU, urgent care and infectiology departments, nurses, clinical microbiologists, technicians, etc.). A plan of action was established on different levels. Communication with the neighbouring hospitals and government was crucial, since the ICU would not be operational for an undetermined period and urgent novel hospitalisation of patients, requiring intensive care, had to be redirected to neighbouring hospitals. On the other hand, a temporary small ICU was set-up in the hospital, with two beds for internal patients, to facilitate the intensive monitoring of post-operative care, acute exacerbations, etc. Because an important construction error of the recently renovated ICU-department's roof seemed to be the underlying cause of the leakage and moist problem, the technical department and the contractor of the roof established a strict timeline of thorough controls, restoration and renovation of the roofing materials. Reparation of the roofing was crucial before any sanitisation procedures could start. Subsequent cleaning and decontamination of the different ICU boxes, with hydrogen peroxide evaporation, finally lead to the negative quantitative analysis of the *Aspergillus* CFU count on March 5th (Table 1).

There is no possible way of knowing how long this problem had been present. Even though HEPA filters are present in the ICU boxes, high *A. fumigatus* colony count was measured at the initial sample collection. A retrospective evaluation (<1 year) of the patients in the ICU ward and the microbiological retrospective evaluation of the records of these patients did not reveal any patient possibly infected with airborne *Aspergillus*.

Conclusion

Immunocompromised patients can experience life-threatening respiratory infections arising from *A. fumigatus*. As such, the causal relationship between the presence of *Aspergillus* conidia in the air and the occurrence of nosocomial invasive aspergillosis urges to reduce the presence of *Aspergillus* in the air of ICU to an absolute minimum level [1,13,14]. The current short communication reports the outbreak of *A. fumigatus* in a small ICU ward. Even though no direct impact on the patients was described, accurate and efficient handling of the delicate situation seemed vital. As such the ICU was only closed for a few weeks. Issues concerning leakage of roofs and mold are very hard to prevent and to control, yet regular air sampling on critical wards could be beneficial. Therefore, the hospital and department of infection prevention decided to invest in a

timely verification of air sampling (and quantification of *Aspergillus* CFU) in the ICU and operating rooms.

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Competing interests

None declared.

Ethical approval

Not required.

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