Fungal infections and construction work

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Background

- Construction work liberates large amounts of fungal spores
- Construction work inside or adjacent to the hospital can cause aspergillosis outbreaks in immunocompromised patients
- Patients at highest risk: transplant recipients (HSCT, SOT), patients receiving chemotherapy for acute leukaemia
- Patients with invasive aspergillosis (IA): mortality > 50%

Examples of outbreaks (1)

- Atlanta: increase in the incidence of IA in renal transplant recipients: 3/16 patients during one month vs. 0/21 during previous 13 months
- Construction work above the ward during previous three months
- Visible dust through the false ceiling and from the staircase
- Air and surface sampling
- Higher spore counts of *Aspergillus* spp. in areas below the construction vs. above it (>200 CFU vs. 2-4)
- Surface samples from false ceilings: 5/8 positive

Arnow et al. Am Rev Respir Dis 1978

Control measures

- Protective barriers around the construction site
- Patients removed from the contaminated ward
- Thorough cleaning, including the tiles of false ceilings
- Result: no new cases of IA

Arnow et al. Am Rev Respir Dis 1978

Examples of outbreaks (2)

- Johns Hopkins, oncology wing
- 2nd floor: leukaemia ward, HEPA+
- 3rd floor: BMT ward, HEPA+
- IA:
  - 1995 10 cases, 1996 29 cases
  - *A.flavus* ↑ (previously *fumigatus*)
  - sinusitis ↑ (vs. pneumonia)

Thio et al. Infect Control Hosp Epidemiol 2000

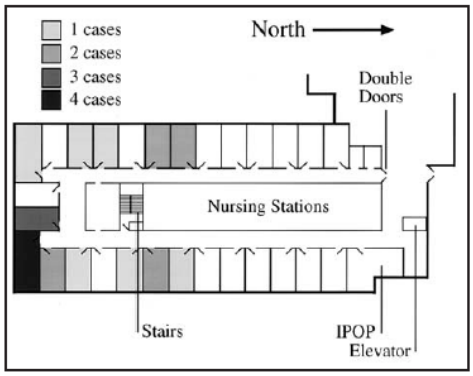
Explanation

- HEPA: pressure?
  - 3/25 patient rooms: negat. pressure
    3/25 patient rooms: ±
  - ward: negative or ± vs. the main building
  - ward: negative vs. staircase
- Air samples:
  - 10/40 positive for *Aspergillus* spp.
  - *A. flavus* 3 CFU/m³ (med)
- Surface samples: patient rooms, HEPA filters
  - 27/120 positive for *Apergillus* spp, HEPA clean

Thio et al. Infect Control Hosp Epidemiol 2000

Explanation & control measures

- Most patients with IA; housed near the staircase
- Construction on the southern and eastern side of oncology wing
- Pressure corrected
- Staircase sealed off
- Portable HEPA filters to ward entrance
- Cleaning
- Result: IA incidence fell to normal level



Thio et al. Infect Control Hosp Epidemiol 2000

CDC/IDSA Guidelines

Recommendations Regarding Mold Infections

Preventing Exposure

Nosocomial mold infections among HSCT recipients result primarily from respiratory exposure to and direct contact with fungal spores (*174*)... Therefore, whenever possible, HSCT recipients who remain immunocompromised should avoid hospital construction or renovation areas (AIII). When constructing new HSCT centers or renovating old ones, hospital planners should ensure that rooms for HSCT patients have an adequate capacity to minimize fungal spore counts through use of high-efficiency (>90%) particulate air (HEPA) filtration (*140,178,179*) (BIII); …correctly sealed rooms, including correctly sealed windows and electrical outlets (*140*) (BIII); high rates of room air exchange (i.e., >12 air changes/hour) (*140,178*) (BIII); and barriers between patient care and renovation or construction areas (e.g., sealed plastic) that prevent dust from entering patient care areas and that are impermeable to *Aspergillus* species (*175,179*) (BIII)….

Hospital construction or renovation areas should have negative air pressure relative to that in adjacent patient care areas

Additionally, HSCT centers should be cleaned with care, particularly after hospital renovation or construction, to avoid exposing HSCT recipients and candidates to mold spores (*174,176*) (BIII)....

Studies with prospecive environmental survaillance during construction activity

Author, year	Techniques used
Streifel et al. 1983	Air sampling for spore counts
Goodley et al. 1994	Air sampling for spore counts, nasal cultures
Overberger et al. 1995	Particle measurements, air sampling for spore counts
Cornet et al. 1999	Air sampling for spore counts, surface cultures by swabs
Raad et al. 2002	Air sampling for spore counts
Cooper et al. 2003	Air sampling for spore counts
Krüger et al. 2003	Surface cultures by gravity air setting plates
Morrison et al. 2004	Air sampling for spore counts
Curtis et al. 2005	Air sampling for spore counts
Berthelot et al. 2006	Air sampling for spore counts, surface cultures by swabs
Hansen et al. 2008	Particle measurements, air sampling for spore counts

Helsinki experience

- HUCH: 1 previous outbreak in HSCT ward
- HSCT ward: 1st floor of the hospital building
- 13 single rooms with HEPA filtration
- October 2005: construction work was started in the immediate vicinity of the ward
- Protective barriers around he construction area
- Five-step environmental surveillance system

5. Aspergillus infections

4. Fungal cultures from patients (colonization)

3. Air samples & fungal cultures of room surfaces (qualitative for airborne & non-airborne)

2. Particle measurements (quantitative)

1. HEPA-filters

Five-step surveillance system

- HEPA-filters had been changed in 2002
- Daily measurements of ventilation channels: no changes in pressure

1. Ventilation channel pressure

Five-step surveillance system

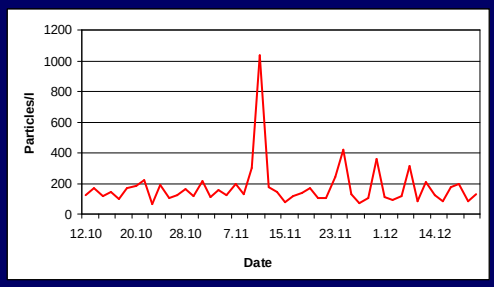
2. Particle counts

1. Ventilation channel pressure

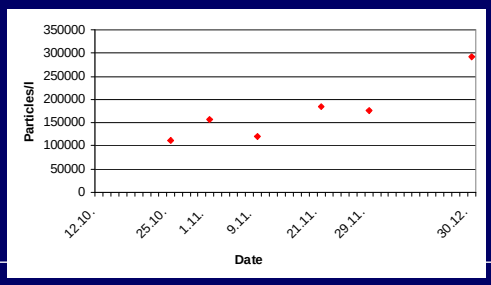
Particle measurements

- particle scanner (IQ Air®, Switzerland)
- optic chamber with laser, air sucked in
- adjusted to measure particles with 0.3 µm diameter
- all patient rooms, 5 times per week for 12 weeks

Median numbers of particles



HSCT ward



outside air

Five-step surveillance system

3. Air samples & fungal cultures of room surfaces

2. Particle counts

1. Ventilation channel pressure

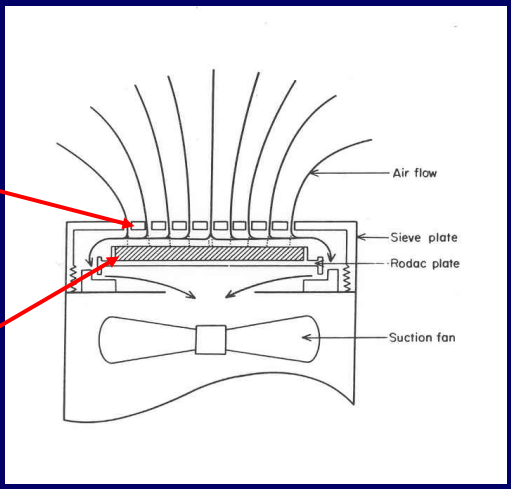
Air sampling: spore counts

- SAS 100 portable air sampler (pbi International®, Italy)
- three randomly selected patient rooms
- sampling once a week

Air sampler

plate with holes (219 holes,Ø 1 mm)

Malt agar plate
Ø 50 mm



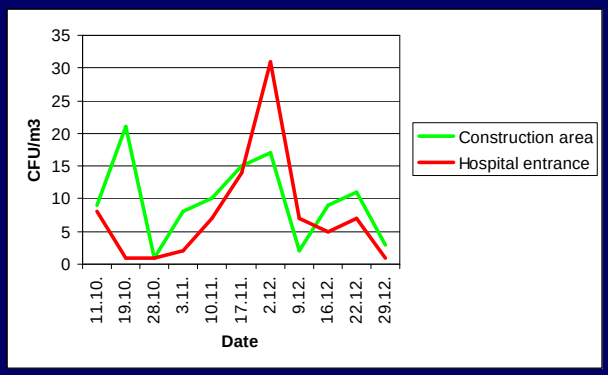
Rhame FS. J Hosp Inf 1985

Spore counts: HSCT ward

Date	Room I	Room II	Room III
11.10.2005	neg.	neg.	pos.*
19.10.2005	neg.	neg.	neg.
28.10.2005	neg.	neg.	neg.
03.11.2005	neg.	neg.	neg.
10.11.2005	*A.niger* 1 CFU	neg.	neg.
17.11.2005	neg.	neg.	neg.
02.12.2005	neg.	neg.	neg.
09.12.2005	neg.	neg.	neg.
16.12.2005	neg.	neg.	neg.
22.12.2005	neg.	neg.	neg.
29.12.2005	neg.	neg.	neg.

**Cladosporium* 1 CFU/m³

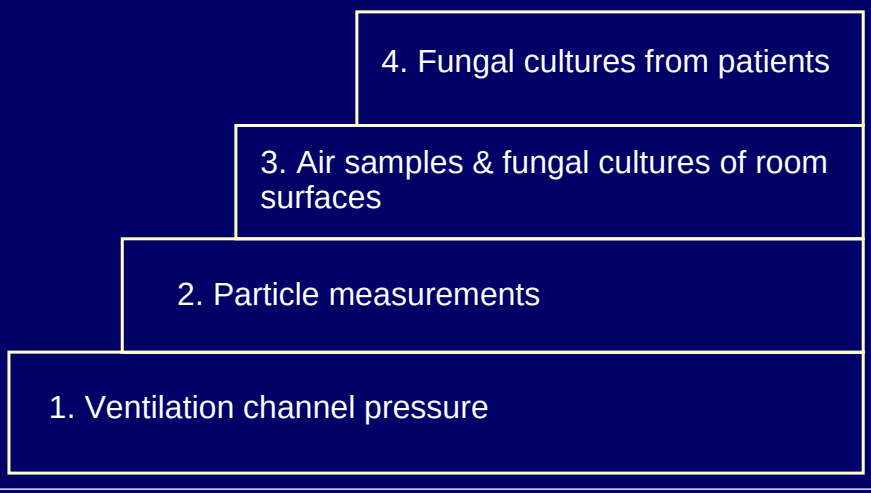
Spore counts: outside air



Fungal cultures of room surfaces

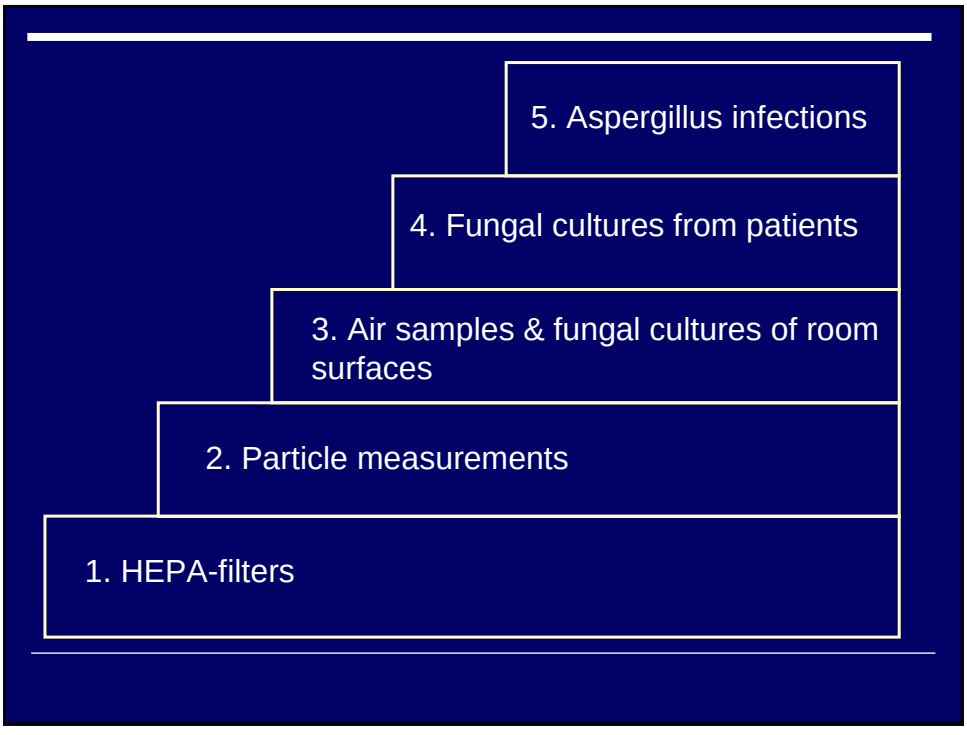
Date	Room I	Room II	Room III
11.10.2005	(+)	(+)	(+)
19.10.2005	*A. fumigatus* 1 CFU/m^3	(+)	(+)
28.10.2005	*A. fumigatus* 1 CFU/m^3	(+)	-
03.11.2005	(+)	-	-
10.11.2005	-	-	*A. versicolor* 1 CFU/m^3
17.11.2005	-	-	-
02.12.2005	-	-	-
09.12.2005	-	-	-
16.12.2005	-	-	-
22.12.2005	-	-	-
29.12.2005	-	-	-

Five-step surveillance system



Oral and nasal colonization

- all patients, three times during the follow-up
- swabs for fungal cultures from both nostrils and dorsum of tongue
- 24 patients, 105 samples
- all 70 nasal swabs negative
- mouth:
  - 18 samples negative
  - 17 positive (*C. albicans* 11, other yeasts 5, *Aspergillus niger* 1 – ”old” IA diagnosis)



Aspergillus infections

Table 1 Characteristics of the 55 patients treated in the ward during the construction work

Reason for hospitalization	*Number of patients*	*Number of patients with nose and mouth cultures*	*Median duration of hospitalization during the construction work, days (range)*
Allogeneic SCT			
SCT, no aGVHD	9	5	28 (1–39)
SCT + aGVHD (high-dose MP)	6	6	30 (26–63)
aGVHD* (high-dose MP)	5	5	23 (21–41)
Other complications	16	5	6 (2–43)
Autologous SCT	7	2	22 (3–28)
Others (acute leukaemia 5, lymphoma 3, multiple myeloma 2, CML in blast crisis 1, stem cell donor 1)	12	1	4 (1–80)

Abbreviation: MP = methylprednisolone.
*SCT performed before the beginning of the construction work.

- median time of follow-up 214 days
- no IA infections

Nihtinen et al, Bone Marrow Transplant 2007

What if things went wrong?

Method	Observation	Interpretation & Action
Ventilation channel pressure	Elevated pressure	HEPA filter filled with dust; change the filters
Particle counts	Counts rising in patient rooms	Malfunction of HEPA filters? Check the filters, find other sources
Air & surface samples	Repeatedly positive	Alarmig; find the source. Cleaning of ward, consider moving the patients elsewhere
Nasal & oral samples	Positive	Patients colonized; consider pre-empitive therapy
Clinical infections	Increasing incidence	Failure of system; start therapy

Conclusions (1)

- Outbreaks of aspergillosis after construction activity can be prevented:
  - protective barriers
  - well sealed patient rooms (isolation protocol, window frames etc.)
  - sealing of air intake ducts if possible
  - in-hospital renovation; negative pressure if possible
  - traffic to and from the construction area; separate route
  - cleaning activity

Conclusions (2)

- In high-risk patient areas function of air filtration should be followed during construction activity
- The role of prospective environmental surveillance during contruction activity is controversial
  - particle measurements; quick, easy, quantitative
  - air & surface sampling; more time consumig but qualitative
  - particle measurements as routine, other samples if indications of elevated counts?