Mould in the Healthcare Environment: Sources and Solutions

Presented by:
Michele E. Slinkard, CIH, CSP
CIH Services, Inc.
Objectives

- Overview of mould
- Sampling methods
- Interpretation of results
- Control methods
What I’ve learned........

• There is good mould – the blue in blue cheese, and the yeast that turns grape juice into wine.
• There is also bad mould that will make susceptible individuals very sick.
• There is a lot of mould between good and bad that we aren’t sure about........
• Due to the amazing amount of information available on the subject of mould, my presentation could last longer than one hour (just kidding)!
Aspergillus

- Ubiquitous mould found in soil, water, decaying vegetation
- Easily transmitted through air
- Most often infects lungs
- Can spread to other organs
- High morbidity/mortality
Aspergillus

- Spores remain viable for months in dry state
- *Aspergillus* conidia bypass host defenses of upper airway and can reach pulmonary alveolar spaces because of small size
- When they reach lungs, they result in infection, colonization, or hypersensitivity
- Aspergillosis is difficult to detect early
Aspergillus

- Patients at increased risk include:
  - Severe granulocytopenia
  - Solid organ transplants
  - Corticosteroid use
  - Diabetes mellitus
  - Major burns
  - Alcoholic liver disease
  - Recent major surgery

- 90% of infections caused by *Aspergillus fumigatus* (also *A. flavus, niger, terreus*)
Aspergillus

- Most hospital outbreaks involved pulmonary disease and have occurred in bone marrow transplant units
- Reservoirs include unfiltered air, ventilation systems, contaminated dust dislodged during hospital construction, carpeting, food, and ornamental plants
Aspergillus

• Could water supply be a source?
• Norwegian study isolated *A. fumigatus* from 60% of tap water samples in pediatric bone marrow unit
• American study from the U. of Arkansas suggests that mould in water may infect patients by aspiration
• Large scale studies needed
Emerging Infectious Fungal Pathogens Impacting Nosocomial Infections

- *Candida albicans*
- *Aspergillus fumigatus, flavus, niger, terreus*
- *Fusarium*
- *Zygomycetes – Mucor, Rhizopus*
- *Acremonium*
- *Chrysosporium*
- *Paecilomyes*
- *Penicillium*
- *Scopulariopsis*
- *Trichoderma*
Stachybotrys chartarum (atra)

- Greenish-black slimy mould
- Growth on high cellulose/low nitrogen content materials (fiberboard, gypsum board, paper, dust, lint)
- Chronic moisture required for growth
- Not often seen in air as viable mould
- 1994 – linked with idiopathic pulmonary hemorrhage in infants (CDC says no proven link)
Stachybotrys chartarum (atra)

- Produce mycotoxins
  - Resulting in allergic sensitization, inflammation, and cytotoxicity in upper and lower respiratory tract
  - Low molecular weight, not volatile
- *Stachybotrys chartarum* has been associated with dermatitis, cough, rhinitis, itching or burning sensation in mouth, throat, nasal passages and eyes.
**Penicillium spp**

- *Penicillium spp.* are widespread and are found in soil, decaying vegetation, and the air.
- *Penicillium spp.* are rare causes of infection (invasive disease) in humans and the disease is known generically as penicilliosis.
- The only known species (among 200) to cause significant disease in humans is *Penicillium marneffei*.
- Highly allergenic mould.
Derived from Latin word meaning paintbrush
**Cladosporium spp**

- Ubiquitous in nature and most commonly encountered mould in the indoor environment
- *Cladosporium* spp. are rare causes of disease in humans, however persons can be sensitized by as little as 400 spores/m$^3$ of air
- Highest concentrations outdoors in late summer and early fall
Chaetomium spp

- Commonly found on deteriorating wood products, including paper & water-damaged drywall
- Emits musty odor and the mould indicates long-standing water issues in the indoor environment
- Chaetomium spp. are among the fungi causing invasive disease with fatal deep mycoses due to Chaetomium atrobrunneum in an immuno-compromised host. Brain abscess, peritonitis, cutaneous lesions, and onychomycosis may also develop due to Chaetomium spp.
Sampling Methodology

• Sampling techniques are evolving
• Not as straightforward as sampling for chemical agents
• Variability of results over time
• Lack of universally accepted exposure limits and numerical standards
• Comparison of indoor/outdoor ratios of moulds is universally accepted
Sampling Methodology

- More than one sampling method may be necessary
- Lack of industry qualification or practice standards for assessors and remediers
- Liability and insurance issues
Sampling Methodology

• Viable Air Sampling Techniques
  – Andersen N6 Impactor
    • Suitable for estimating fungal diversity in indoor air
    • Sample at 28.3 lpm
  – Bioscience International SAS
    • 90, 180, 100 liters per minute
  – RCS, AGI-30
  – Laboratory culture requires 5-7 days
Other Sampling Techniques

• Spore Trap Air (Air-O-Cell, Allergenco)
  – Viability of spore is unknown
  – Optical techniques
  – Rapid turnaround (as little as 3 hours)
Other Sampling Techniques

• PCR (polymerase chain reaction)
  – DNA typing methods for fungi & bacteria
  – Can identify to genus and species
  – Does not provide viability of organism
  – Quick turnaround time (several hours is possible)
Other Sampling Techniques

• Wipe Samples
  – Sterile swab
  – Direct microscopic
  – Cultured onto plates

• Bulk Samples
  – Sterile container
  – Cultured in laboratory
Selection of Laboratory

• AIHA Accredited (EMLAP)
  – Personnel qualifications
  – Quality control
  – Participation in EMPAT Proficiency Tests
  – Adequate facilities
  – Written SOPs
  – Inspection by AIHA every 2 years
Selection of Laboratory

- Access to information
  - Explanation of results
  - Interpretation of data
- Laboratory report format
- Turn around time
- Pricing
Interpretation of Results

• Culturable mould samples
  • <250 CFU/m³ (low)
  • >1,000 CFU/m³ (elevated)

• Bulk samples
  • <25,000 CFU/gram (low)
  • >1 x 10⁶ CFU/gram (elevated)

• Swab samples
  • <10,000 CFU/in² (low)
  • 10,000 – 100,000 CFU/in² (moderate)
  • >100,000 CFU/in² (elevated)
Other Guidelines

• Comparison of indoor/outdoor ratios
• Complaint vs. Non-complaint areas
• Consider air exchange rates and activity levels in building, weather, season
• Rank order assessment and concentration of the microbe
Other Guidelines

• Predominant fungal genera, opportunistic, pathogenic, or water indicator organisms such as *Chaetomium*, *Stachybotrys*, *Rhodotorula*, *Trichoderma*, and *Scopulariopsis*

• Generally indoor concentrations are less than outdoors; however, there is always a potential bias from infiltration of outdoor air, poor housekeeping, excessive indoor relative humidity or potential contamination sources

• These guidelines are intended to be a “reactionary threshold” to incite further investigation.
Spore Trap Tips

• Comparison of outdoor/indoor
• Complaint vs. Non-complaint
• Water indicator organisms
• Primary colonizers in damp areas
  – *Aspergillus/Penicillium*
• Tertiary colonizers
  – *Chaetomium, Stachybotrys*
• Presence of hyphal fragments
Spore Trap Tips

- Ascospores and basidiospores represent the entrance of inadequately filtered outdoor air.
- In winter months in northern climates, outdoor spore levels may be less than indoor with no significant amplification.
Protected Environments

- Increased air changes, positive pressure room, HEPA-filtered air
  - Total pathogens
    - <0.1 CFU/m$^3$
    - >1.0 CFU/m$^3$, need to investigate
  - Gross counts
    - <15 CFU/m$^3$ (room temperature)
    - <2 CFU/m$^3$ (37 degrees)
Why ACGIH does not recommend TLV for Bioaerosols

- Mixtures of microorganisms are complex
- Variability in human response
- Cannot rely on a single sampling method
- Information relating culturable or countable bioaerosol concentrations to health effects is generally insufficient to predict dose/response relationships
Case Study

- 53 year old female presents with dry cough
- Construction project in adjacent area of hospital
- Portable A/C unit, slimy water and hoses
- Thick layer of dust throughout office
- Female is diagnosed with “ground glass opacity”
- Airborne spore testing indicated 80% of spores were Aspergillus/Penicillium-like
- Viable (Culturable) testing in progress
- Bronchoscopy in progress
Mould Prevention

• HVAC inspection and maintenance
• High moisture sources
  – Indoor pools, hot tubs, steam rooms, saunas, decorative fountains, walk-in refrigerators/freezers, attached greenhouses, and laundry/washrooms
• Roof problems
• Grading problems
Mould Prevention

• New construction
  – Floor drains below appliances that use water
  – Installation of drywall above floor level to minimize wicking in case of flooding incidents
  – Use of water-resistant materials

• Maintenance staff
  – 1\textsuperscript{st} responders
  – Inspection (checklist)
    • Stained ceiling tiles, odors, bubbling of paint, rust stains

• Have a plan for unexpected water intrusion events
Removal of Mould Spores (hospital setting)

- Air filtration units in rooms
- UV light source in ductwork
- Replace carpet with floor tile
- Improve housekeeping
- 10 year study
Construction Projects

- Release of mould, dust or soil contaminated with fungal spores or bacteria
- Mould spores settle very slowly
- Enter hospitals through:
  - Improperly sealed windows/barriers
  - Defective ventilation systems
  - Incorrect pressurization of patient care areas
  - Inadequate air exchange rate
  - Improper maintenance of HVAC components
Strategies (Health Canada Model)

- Type A – Removal of ceiling tiles
- Type B – Small-scale, short duration activities (accessing chases, cutting of walls)
- Type C – Sanding of walls, removal of floor coverings, new wall construction
- Type D – Major demolition and construction
Strategies
(Health Canada Model)

• Group 1 – Lowest risk (Office Areas, Public Areas)
• Group 2 – Medium risk (Outpatient Clinics, Admission/Discharge)
• Group 3 – Medium to high risk (ER, Radiology, PACU)
• Group 4 – Highest risk (ICU, ORs)
Matrix to Determine Class of Construction Infection Controls

<table>
<thead>
<tr>
<th>Risk Group</th>
<th>Type A</th>
<th>Type B</th>
<th>Type C</th>
<th>Type D</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>I</td>
<td>II</td>
<td>II</td>
<td>III/IV</td>
</tr>
<tr>
<td>2</td>
<td>I</td>
<td>II</td>
<td>III</td>
<td>IV</td>
</tr>
<tr>
<td>3</td>
<td>I</td>
<td>III</td>
<td>III/IV</td>
<td>IV</td>
</tr>
<tr>
<td>4</td>
<td>I-III</td>
<td>III/IV</td>
<td>III/IV</td>
<td>IV</td>
</tr>
</tbody>
</table>
Construction Infection Controls

- **Class 1** - vacuum after ceiling tile removal, minimize patient’s exposure to work
- **Class 2** – Minimize dust (use drop sheets, seal work area at openings, disable ventilation system, wet wipe and HEPA vacuuming
- **Class 3** – Consult with IC, use containment, move high risk patients, flush water lines before re-occupancy
- **Class 4** – IC will inspect, provide anteroom, mandatory shoe covers and walk-off mats
Remediation

• Communication
  – EHS, facilities management, building occupants

• Personnel
  – Trained individuals

• PPE
  – Full-face APR (stacked cartridges)
  – Tyvek coveralls
  – Gloves
  – Tools
Remediation

• **Hygiene**
  – Wash hands after exiting enclosure
  – Remove coveralls in “dirty room”
  – Remove respirator in change area
    • Disinfect respirator

• **Containment**
  – Isolate work area using plastic sheeting
  – Use exhaust fan with HEPA to generate negative pressure
  – Construct 2-stage decontamination room with changing area and a dirty room
Remediation

• Control of exposure to adjacent areas
  – Vacating adjacent areas is recommended for individuals with reduced immune systems, infants, recent surgery patients, people with chronic lung disease or asthma
  – In general, there are fewer occupant complaints if you vacate all adjacent spaces
Remediation

• Painting and applying bleach
  – Exhaust fan outside building
  – Make sure adjacent outside windows are closed, discharge is not near air intake

• Apply bleach to visible fungal growth prior to removal
Remediation

• Removal of contaminated materials
  – Sealed plastic bags
  – Disinfect outside of bags
  – Dispose of with general trash

• Cleaning of containment area
  – HEPA vacuum
  – Wiped with detergent solution

• Final inspection
  – Visual
  – Air sampling
Response to Water Incidents
(flooding, plumbing leak, roof leak, potable water leak, sewage back-up)

• Remove ceiling tile within 24-48 hours
• Removed water-damaged plaster and insulation within 24-48 hours
• Block walls – scrub with detergent/bleach
• Furniture dried within 24 hours
• Discard furniture made of particle board
• Files/paperwork should be removed from the area, photocopied, and discarded
Response to Water Incidents
(flooding, plumbing leak, roof leak, potable water leak, sewage back-up)

• Carpet wet with sewage – discard
• Carpet wet with “clean” water
  – <48 hours, steam clean carpets, dry within 12-24 hours of treatment
  – >48 hours, discard
• Use carpet removal procedure
• Use outside specialist for remediation
Conclusions

• The presence of mould and dampness in the environment can cause adverse health effects
• Use appropriate sampling methodology
• Use qualified consultant/laboratory
• Improve housekeeping where feasible
• Eliminate water intrusion
• Plan ahead for construction projects to minimize airborne spore generation
More Information

- Bioaerosols Assessment and Control – ACGIH (1999)
- Recognition, Evaluation, and Control of Indoor mould – AIHA (2008)
- “Controlling Hospital-Acquired Infections: Role of the Industrial Hygienist” - AIHA (2009)
- WHO Guidelines for Indoor Air Quality: Dampness and Mould, World Health Organization - 2009
Thank you!