Postflood Pseudofungemia Due to \textit{Penicillium} Species

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We report an outbreak investigation of fungemia due to \textit{Penicillium} species after prolonged flooding of a Thai hospital. Contaminated rubber diaphragms of blood culture bottles were identified, and the pseudo-outbreak was resolved after environmental cleaning, use of high-efficiency particulate air filtration, and strict compliance with basic infection control practices for blood culture procurement.

Nosocomial outbreaks due to fungi have been associated with devastating opportunistic infections among immunocompromised hosts after proximity to construction, renovation, false ceilings, and fireproofing [1–3]. Pseudofungemia is characterized by a false increase in the number of fungemic cases without legitimate clinical explanation [4]. Such clinical presentations can be enigmatic for providers and for infection control professionals given the rare incidence of fungemia in immunocompetent hosts. These clinical scenarios may result in the unnecessary use of antifungal treatment, adverse drug reactions, excess costs, and redistributed use of limited resources [4, 5]. We report the investigation of fungemia due to \textit{Penicillium} species after flooding at a Thai hospital.

\section*{METHODS}

\subsection*{Setting, Outbreak Investigation, and Case Definition}

Thammasat University Hospital is a 600-bed, tertiary-care hospital in central Thailand. The hospital was closed on 14 October 2011 because of progressive flooding, which eventually reached a ground floor, with a peak height of 3 meters. The water level gradually decreased to complete dryness on 2 November 2011. During the interval from 2 to 24 November 2011, the emergency department (ED), outpatient units, and microbiology laboratory underwent site inspections to reopen the hospital; an infection control protocol and modified checklist from the Centers for Disease Control and Prevention were used [6]. Owing to budget constraints, the ED ceilings and walls were not repaired prior to reopening this area. On 25 November 2011, limited areas within the hospital reopened, inclusive of the ground-level ED and some outpatient units. On 12 December 2011, selected inpatient units including Medicine and an intensive care unit reopened. On 14 December 2011, the infection control division was initially notified by the microbiology laboratory that 4 hospitalized patients had positive blood cultures for \textit{Penicillium} species; all cultures were drawn in the ED and there were no incident cases detected elsewhere since the hospital reopened. An outbreak investigation was initiated, with a case defined as a patient with \textit{Penicillium} species isolated from 1 or more blood culture specimens. Epidemiological and clinical data were obtained from patients’ medical and nursing records. Patients currently hospitalized were examined. Blood culture records from the microbiology laboratory were reviewed to determine the baseline incidence of fungemia caused by \textit{Penicillium} species in the 12 months prior to this cluster of cases.

\subsection*{Microbiological and Environmental Evaluation}

Given the hypothesis that pseudofungemia resulted from environmental contamination in the ED after the flood, environmental cultures and air sampling cultures were obtained in the ED and construction records were reviewed. The walls, ceilings, and water pipes of the ED were examined. The procedures for blood culture procurement in the ED, inclusive of specimen transport and processing to the laboratory, were assessed. The standard method for blood culture procurement was skin disinfection with 2% chlorhexidine with alcohol and an interval wait time of 2 minutes before venipuncture with a sterile syringe using aseptic technique. Blood was inoculated into 2 aerobic culture bottles after cleansing the rubber diaphragms of the blood culture bottles with alcohol. At the microbiology laboratory, blood was inoculated onto 1 blood agar and 1 chocolate agar plate (BBL, Cockeysville, Maryland). The plates were streaked using flamed large loops, then inoculated upright for the first 24 hours in a 35°C carbon dioxide incubator.

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All laboratory processes were performed under a biosafety cabinet hood of a biosafety level 2+ standard laboratory [7].

To determine airborne environmental contamination, air sampling using a Microbial Air Sampler (MAS)-NT 100 (Merck, Darmstadt, Germany) was performed at 5 ED sites (sites A–E). Sites A and B were used to obtain blood cultures from ED patients, and sites C–E were a mini operation room, nursing area, and high-risk triage area, respectively. The MAS-NT 100 at a flow rate of 100 L/min was used for air sample collection. It is a single-stage impactor machine capable of sampling 100 L of air per minute. Intake of sampled air through a plate perforated with 300 holes and microbial aerosol was collected on an agar growth medium surface within a standard 90-mm Petri dish. Sites C–E were opened for service on 25 November 2011, whereas air contamination of sites A and B delayed reopening for service until 10 December 2011. Air samples were inoculated onto sterile blood and Sabouraud agars at each site; the standard reference of <500 colony-forming units (CFU)/m³ total fungal bioburden was the upper limit of normal [8]. Surface environmental contamination in the ED was investigated at sites A and B by culturing surfaces of alcohol gel bottles, povidone iodine/chlorhexidine bottles, gloves, blood culture carts, and rubber diaphragms of 3 randomly selected blood culture bottles from each cart. Fungal identification was performed according to Clinical and Laboratory Standards Institute guidelines [9].

**RESULTS**

**Epidemiological Findings**

In the interval from 14 to 16 December 2011, 10 cases of *Penicillium* fungemia were identified, compared with only 2 cases of fungemia due to *Penicillium marneffei* during the prior 12 months. All patients had blood cultures drawn in the ED on admission (Table 1). The median patient age was 43 years (range, 5–84 years); most were without any underlying comorbidity or immunosuppression. The median length of hospital stay was 2 days (range, 1–4 days); all patients were discharged from the hospital, most prior to identification of positive blood cultures. Follow-up blood cultures were all negative and no patient received antifungal therapy. Observation of blood culture procurement revealed good compliance with the protocol, except for use of 10% aqueous povidone iodine instead of 2% chlorhexidine with alcohol and lack of 2-minute contact time prior to venipuncture. Blood culture rubber diaphragms were disinfected with alcohol. No break in inoculation techniques was detected at the microbiology laboratory.

**Microbiological and Environmental Contamination**

Environmental examination of the ED revealed evidence of fungal contamination on the ceilings and walls of sites A and B, but no water pipe leak. There was no evidence of fungal contamination at sites C–E. Cultures of environmental surfaces including blood culture carts, alcohol gel bottles, povidone iodine/chlorhexidine bottles, gloves, and equipment used to obtain blood cultures were negative for *Penicillium* species. However, 4 *Penicillium* species were recovered from 3 of 3 rubber diaphragms of the blood culture bottles at site A. Air sampling at sites A and B revealed a total fungal bioburden of 730–830 CFU/m³ (reference, <500 CFU/m³), whereas the fungal bioburden at sites C–E was 160–440 CFU/m³. *Penicillium* and *Aspergillus* species were the most common fungal pathogens recovered at sites A and B, whereas *Phialophora* species and **Table 1. Demographic and Clinical Characteristics of 10 Hospitalized Patients With Postflood Pseudofungemia With *Penicillium* Species Identified During a 72-Hour Interval**

<table>
<thead>
<tr>
<th>Case</th>
<th>Age/Sex</th>
<th>Location Where BCs Were Drawn (Positive Sets)</th>
<th>Underlying Diseases</th>
<th>Final Diagnosisa</th>
<th>Hospital Length of Stay (d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>84/F</td>
<td>ED (1)</td>
<td>HTN</td>
<td>Aspiration pneumonia</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>54/M</td>
<td>ED (1)</td>
<td>None</td>
<td>CAP</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>5/M</td>
<td>ED (1)</td>
<td>None</td>
<td>Severe tonsillitis</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>65/M</td>
<td>ED (2)</td>
<td>None</td>
<td>CAP</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>76/F</td>
<td>ED (2)</td>
<td>HTN, DM</td>
<td>Viral gastroenteritis</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>45/F</td>
<td>ED (1)</td>
<td>DM</td>
<td>DKA</td>
<td>4</td>
</tr>
<tr>
<td>7</td>
<td>71/M</td>
<td>ED (1)</td>
<td>HTN, CVA</td>
<td>Viral syndrome</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>30/F</td>
<td>ED (2)</td>
<td>None</td>
<td>Dengue fever</td>
<td>2</td>
</tr>
<tr>
<td>9</td>
<td>36/M</td>
<td>ED (1)</td>
<td>None</td>
<td>Viral gastroenteritis</td>
<td>1</td>
</tr>
<tr>
<td>10</td>
<td>41/F</td>
<td>ED (1)</td>
<td>None</td>
<td>Leptospirosis</td>
<td>3</td>
</tr>
</tbody>
</table>

Abbreviations: BC, blood culture; CAP, community-acquired pneumonia; CVA, cerebrovascular accident; DKA, diabetes ketoacidosis; DM, diabetes mellitus; ED, emergency department; F, female; HTN, hypertension; M, male.

a All survived hospitalization.
Syncephalastrum species were sporadically identified at sites C–E. There were no construction or renovation projects under way at or near the ED.

Implementation of Infection Control Policy for Obtaining Blood Culture

After notification of the outbreak, we provided an educational and compliance session to ED healthcare workers regarding basic infection control practices for obtaining blood cultures. High-efficiency particulate air filters were introduced at sites A and B on 14 December 2011. Room decontamination with manual cleaning and 5% hydrogen peroxide vapor was performed; contaminated walls and ceilings were manually cleaned daily with 1:10 sodium hypochlorite at sites A and B for 2 weeks. We changed the solution for skin disinfection and for cleaning the rubber diaphragms of the blood culture bottles to 2% chlorhexidine with alcohol and emphasized the need to wait for 2 minutes’ contact time after skin disinfection prior to venipuncture. Monitored compliance was 100% for these basic infection control practices. Ongoing surveillance identified no new fungemia cases through 25 March 2012, 3 months after the last identified pseudofungemic case.

DISCUSSION

Pseudofungemia has been previously reported in association with hospital construction and renovation [1, 10–12]. To our knowledge, this is the first report of postflood pseudofungemia and our findings are clinically relevant for a number of reasons. First, the role of manual environmental cleaning and thorough area decontamination necessitates, but is not limited to, containment of contaminated sites, cleaning walls with 1:10 sodium hypochlorite, fixing water pipe leakage, and use of hydrogen peroxide vaporizer to help minimize fungal bio-burden. Second, our findings portray the need for strict compliance with basic infection control measures for blood culture procurement, especially during and after flood exposure.

We acknowledge limitations related to this study. First, since air sampling was not performed prior to reopening of the ED. Hence, the true magnitude of fungal burden at the time of the pseudo-outbreak was not able to be assessed. Second, the real cause of the pseudo-outbreak cannot be concluded with certainty, since patients’ skin cultures and molecular analysis of the contaminated items were not performed to confirm the relatedness of the Penicillium species strains. However, our careful systematic investigation strongly suggested the association between pseudofungemia and the contaminated rubber diaphragms as well as lapses in infection control practices in blood culture procurement.

In conclusion, this outbreak investigation suggests that excess fungal aerosolization during and after flood exposure was associated with pseudofungemia among hospitalized Thai patients. Prompt recognition and initiation of the outbreak resulted in timely implementation of appropriate control measures and averted exposure to antifungal therapy and excess length of stay. Our findings support strict compliance with infection control practices for obtaining blood cultures and for environmental decontamination before reopening of hospitals after flood exposure. These efforts require effective collaboration between infection control professionals, technicians, and clinical teams.

Notes

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Potential conflicts of interest. L. M. M. is a consultant for GlaxoSmithKline. All other authors report no potential conflicts.

All authors have submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. Conflicts that the editors consider relevant to the content of the manuscript have been disclosed.

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