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A cluster of nosocomial Legionnaire's disease linked to a contaminated hospital decorative water fountain

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Abstract

Background—Nosocomial outbreaks of Legionnaire's disease have been linked to contaminated water in hospitals. Immunocompromised patients are particularly vulnerable and, when infected, have a high mortality rate. We report the investigation of a cluster of nosocomial pneumonia due to *Legionella pneumophila* serogroup 1 that occurred among patients on our stem cell transplantation unit.

Methods—We conducted a record review to identify common points of potential exposure, followed by environmental and water sampling for *Legionella* spp. from those sources. We used an air sampler in an attempt to detect aerosolized *Legionella*, and pulsed-field gel electrophoresis to compare clinical and environmental isolates.

Results—The most likely sources identified were the water supply in the patients' rooms and a decorative fountain in the radiation oncology suite. Samples from the patients' rooms did not grow *Legionella* species. Cultures of the fountain, which had been restarted 4 months earlier after being shut off for 5 months, yielded *L. pneumophila* serogroup 1. The isolates from both patients and the fountain were identical by pulsed-field gel electrophoresis. Both patients developed pneumonia within 10 days of completing radiation therapy, and each reported having observed the fountain at close range. Both patients' infections were identified early and treated promptly, and both recovered.

Conclusions—This cluster was caused by contamination of a decorative fountain despite its being equipped with a filter and ozone generator. Fountains are a potential source of nosocomial Legionnaire's disease despite standard maintenance and sanitizing measures. In our opinion, fountains present unacceptable risk in hospitals serving immunocompromised patients.

Keywords

Legionnaire's; *Legionella*; nosocomial; fountain; water feature

BACKGROUND

Nosocomial outbreaks of Legionnaire's disease have been linked to contamination of hospital water supplies in numerous reports (1–3). Elderly and immunocompromised patients (4) are

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particularly vulnerable to Legionnaire's disease and, when infected, have a high mortality rate (5). The infection is transmitted via contaminated aerosol or, less frequently, aspiration of contaminated water (1,2,6–8).

In November 2007, the National Institutes of Health Clinical Center experienced its first cases of nosocomial Legionnaire's disease. The cluster, due to *L. pneumophila* serogroup 1, occurred among patients hospitalized on our stem cell transplantation unit; to our knowledge, it is the first reported occurrence of nosocomial Legionnaire's disease traced to contamination of a decorative fountain in a hospital.

PATIENTS AND METHODS

In November 2007, two cases of pneumonia due to *Legionella pneumophila* serogroup 1 were reported on the stem cell transplantation unit in patients with leukemia who had been hospitalized continuously for more than 2 weeks. Suspicion of a nosocomial source prompted an epidemiological and microbiological investigation.

A case of Legionnaire's disease was defined as pneumonia in any patient with a respiratory specimen positive for *L. pneumophila* by polymerase chain reaction assay or culture, or with detectable *Legionella* antigen in a urine sample. Case finding for Legionnaire's disease was performed by electronic searches of the microbiology database. Case finding for undiagnosed pneumonias was conducted by electronic searches of the medical records database for the term "infiltrate" and the diagnosis of pneumonia.

We conducted a prompt and detailed review of the 2 patients' medical records to identify common points of potential exposure. Once such sources were ascertained, we obtained environmental swabs and 50-ml water samples from those sources for *Legionella* culture. Water samples and swabs were collected in sterile containers from showers, sinks, and toilets in each patient's room, and from other sources of potential common exposure.

Water samples were filtered through 0.22 uM polycarbonate filters (Nucleopore). Filters were then resuspended in 10 ml of the respective source water. Swabs were resuspended in 1 ml of water from the respective source. All specimens were decontaminated in 0.2M KCl-HCl buffer for 15 minutes and plated onto the following media: buffered charcoal yeast extract (BCYE) agar; BCYE agar with polymyxin B, anisomycin, and vancomycin (PAV); BCYE agar with glycine and PAV (Remel, Lenexa, Kansas); and BCYE agar with cephalothin, colistin, vancomycin, and cycloheximide (BD Diagnostic Systems). Cultures were incubated in a humid environment for 10 days at 37°C. After DNA digestion by *Sfil* restriction enzyme (New England BioLabs), pulsed-field gel electrophoresis was used to compare clinical and environmental *Legionella* isolates.

SAS Super 100 surface air samplers (Bioscience International) were loaded with sheep blood agar, Sabouraud agar with dextrose, and BYCE agar plates in an attempt to detect aerosolized *Legionella*. The air samples were collected 1 day after the water samples, at a point about 0.6 meters in front of the fountain.

RESULTS

Patients

The two patients were male, 41 and 36 years old, with myelodysplastic syndrome and acute promyelocytic leukemia, respectively, and were undergoing myeloablative conditioning for allogeneic stem cell transplantation. Each was admitted to the hospital 2 weeks prior to the onset of pneumonia. The first patient was admitted on October 14, 2007, underwent radiation

from October 16 through October 19, and developed fever, cough, and hypoxemia on October 29. The second patient was admitted on October 29, 2007, underwent radiation from October 30 through November 2, and developed fever and hypoxemia on November 12. Patient interviews and review of medical records identified only 2 sources of exposure to water in the two weeks preceding onset of symptoms: the water supplies in the patients' rooms and a decorative fountain in the radiation oncology suite (figure 1). The patients had undergone no dental or pulmonary procedures within the incubation period, and had no other exposure to water. The fountain, supplied by the building's municipal water source, had 2 layers of waterfalls which were potential sources of aerosols. The patients were housed in private protective isolation rooms 2 doors apart, and neither had entered the other's room. The rooms were supplied by single-pass, high-efficiency particular air (HEPA)-filtered air and were maintained at positive pressure with respect to the unit. Both patients had received total body irradiation as a component of pre-transplant conditioning and each had made 8 visits to the radiation oncology suite over a 4-day period. Neither patient was neutropenic at the time of radiation therapy, and neither wore a mask during visits to the radiation suite. Patients passing from the waiting area to the radiation suite had to pass within 1.6 meters of the fountain. In both cases, the last dose of radiation therapy was administered 10 days before the onset of symptoms. Laboratory confirmation of *L. pneumophila* serogroup 1 infection in both patients was made by positive results of culture and polymerase chain reaction assay of bronchoalveolar lavage fluid; a urine test revealed *Legionella* antigen for 1 patient. Both patients were treated with levofloxacin and recovered uneventfully.

Environmental Sampling

None of the water, faucet, or shower cultures collected in the patient rooms, and none of the cultures from the ice machine on the stem cell transplantation unit grew *Legionella* species. However, *L. pneumophila* serogroup 1 was recovered from samples of water from the decorative fountain. The isolates from both patients and the fountain were identical by pulsed-field gel electrophoresis (Figure 2). Both patients developed pneumonia well within the incubation period (2–19 days)(9) after exposure to the fountain, and on subsequent interview, each reported having lingered and observed the fountain at close range on at least 2 occasions.

Fountain cultures also yielded prolific growth of other microorganisms, including potential pathogens for this patient population: *Mycobacterium mucogenicum*, *M. chelonae*, *Pseudomonas* species, *Acidovorax* species, *Flavobacterium* species, *Sphingomonas* species, and molds. Cultures of the air samples were overgrown with bacteria, so we could not determine whether they contained *Legionella* species (figure 3).

Features of the Fountain

A review of the fountain's construction and maintenance was conducted to determine the cause of *Legionella* contamination. The decorative fountain, installed in 2005 at the time of construction of the new Mark O. Hatfield Clinical Research Center, was initially equipped with a chlorine cartridge and a 2-uM filter, both of which were intended to prevent contamination by *Legionella* species. and other potential nosocomial pathogens. When the fountain was initially installed, the chlorine odor was so unpleasant as to be intolerable to patients and staff. In an effort to mitigate the odor, the fountain was retrofit with an ozone generator and a 1-uM filter, and the chlorine treatments were discontinued. The ozone generator was the sole means of chemical disinfection for the 18 months before this cluster occurred. Review of maintenance records documented weekly cleaning of the fountain, quarterly deep cleaning and flushing of the fountain and pipes, and appropriate upkeep of the filter and ozone generator. The fountain was turned off in February 2007 for installation of radiation therapy equipment and abatement of mold growth in the ceiling over the fountain, and the fountain was restarted in June 2007.

A *Legionella* culture taken from the lower pool in July, 3 months before the first case was identified, yielded negative results at a commercial laboratory.

Inspection of the fountain's architecture revealed other potential opportunities for contamination. Water collected in an 46-cm-deep basin behind the top of the fountain and cascaded over the top (figure 1). A proportion of the water that circulated through the pump was channeled through the ozone generator and the filter with each pass. Water in the lower pool, which contained plastic toys that encouraged close attention, was automatically supplemented with unfiltered municipal "make up" water. The pipe that recirculated water from the lower pool to the top of the fountain contained stagnant water when the fountain was turned off, likely creating conditions favorable for growth of *Legionella*. Although that pipe was flushed with a cleaning solution when the fountain was restarted, the disinfectant may not have penetrated any scale or biofilm that had formed in the stagnant water. Water from the lower pool, supply pipe, pump, and drains all grew *L. pneumophila* serogroup 1.

Case Finding

Review of records from the Radiation Oncology Department, microbiology laboratory, and Radiology Department failed to identify other patients who had signs and symptoms consistent with either Legionnaire's disease or undiagnosed pneumonia from June through December 2007. We were unable to identify any patients with exposure to the decorative fountain who had infections attributable to the other organisms isolated from cultures of the fountain. Serologic testing for exposure to *Legionella* was positive for 2 of 28 staff members who worked near the fountain and 1 of the 10 others who collected water samples during the outbreak investigation. None of the 3 seropositive employees reported a respiratory illness during the 6-month period after the fountain was restarted in June 2007 and before it was permanently drained in December 2007. There have been no additional cases of Legionnaires disease since the fountain was drained.

DISCUSSION

Two hospitalized patients who were profoundly neutropenic because of myeloablative pretransplant conditioning regimens developed clinical *Legionella* pneumonia. The patients acquired their infections as a result of exposure to a contaminated water feature in our radiation oncology suite. Contamination of the 30-month-old decorative fountain was likely facilitated by allowing the pipes that supply and recirculate water to the fountain to stand with stagnant water in them for a period of 4 months before restarting the water flow. Despite being equipped with a filter and an ozone generator, the combination of which should have minimized colonization with *Legionella* species., the fountain became heavily contaminated with *L. pneumophila*. Initial contamination probably occurred due to mixing of filtered water with unfiltered municipal "make up" water in the lower basin of the fountain. Stagnation in the pipe when the fountain was off likely promoted development of biofilm, an environment in which *Legionella* species particularly thrive and resist disinfection. When the fountain was restarted, water that had stagnated for 4 months in a pipe was recirculated through the fountain. It is not clear why the result of the culture performed in July 2007 was negative; possibilities include sampling error and inadequate culture technique at the commercial laboratory. The 2 patients' exposure to the fountain occurred in October and early November, more than 4 months after the fountain was restarted. Outbreaks of Legionnaire's disease and Pontiac fever been linked to fountains (10–14), but we are not aware of any prior published cases of nosocomial *Legionella* infection that have been definitively linked to a hospital decorative fountain or water feature.

Though less effective than high levels of chlorine compounds, (15,16), ozone has been considered an effective disinfectant for *Legionella*-contaminated water at varying temperatures

and degrees of turbidity (17). An ozone concentration of 1 to 2 mg/L controlled *Legionella* in an experimental model system in varying conditions of temperature and turbidity. (17) However, in a real plumbing or fountain setting it is difficult to maintain this level of ozone residual throughout the system due to continuous decomposition of ozone (18). Furthermore, in a model system, ozone did not affect the population of *L. pneumophila* within a biofilm. (16) With each pass through the fountain's pump, a proportion of the water was treated with ozone. That the ozone did not remain for sufficient time to provide an enduring effect against potential contamination seems likely (19).

Our efforts at case finding among patients and health care workers revealed no undiagnosed illnesses attributable to *Legionella*. We are reasonably confident no patient cases were missed, because virtually every patient in our institution who develops nosocomial pneumonia has a diagnostic bronchoscopy and every bronchoalveolar lavage specimen is tested for *Legionella* by culture and polymerase chain reaction assay. The serosurvey and symptom screen of employees with potential high-level exposure to the fountain yielded no staff members who had both detectable *Legionella* antibodies and compatible symptoms during the 6-month period after the fountain resumed function. Subclinical exposure to *Legionella* has been demonstrated in nonhospital outbreaks (20) but is estimated to be uncommon among health care workers in outbreaks of nosocomial Legionnaire's disease (21).

Fountains and other water features are a potential source of nosocomial Legionnaire's disease despite standard maintenance and sanitizing methods. The fountain was drained following the collection of specimens and it will be removed. In our opinion, decorative fountains and water features present unacceptable risk in hospitals serving immunocompromised patients.

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Figure 1.
Decorative fountain from which *Legionella pneumophila* was isolated. Water cascaded from a deep reservoir over the top panel **(A)** into the upper pool **(B)**, and flowed down a smaller lower panel **(C)** into the bottom pool **(D)**. Water in the lower pool was supplemented with unfiltered municipal "make up" water. Water from the lower pool, which contained plastic toys that encouraged close attention, recirculated to the top of the fountain via a pipe behind the fountain. This pipe contained stagnant water when the fountain was turned off, likely creating conditions favorable for growth of *Legionella*. A proportion of the pumped water was channeled through an ozone generator and a 1-uM filter. Water from **B, D,** the supply line to **A**, and the drains from **D** all grew *L. pneumophila* serogroup 1.

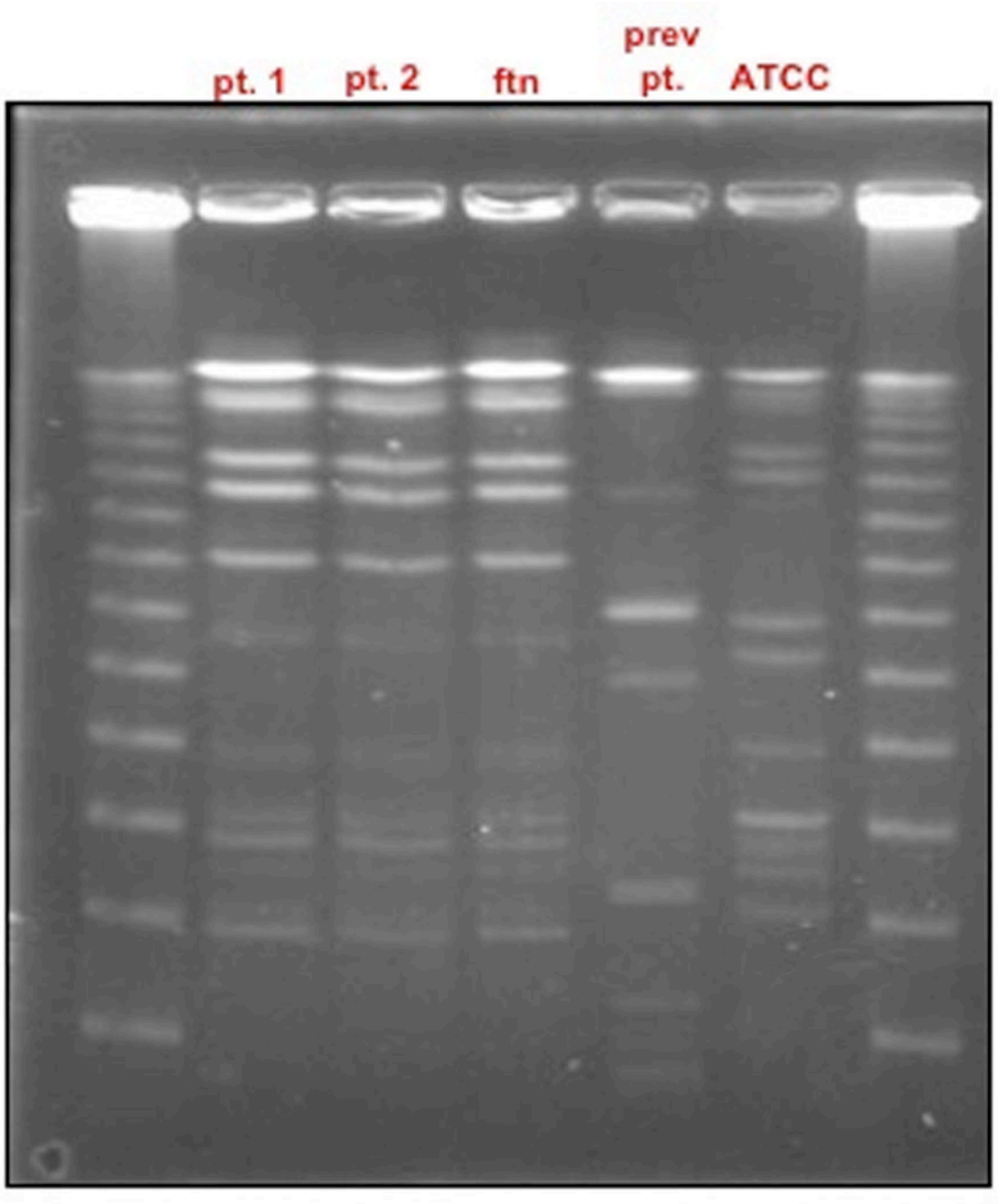

Figure 2.
Banding patterns determined by pulsed-field gel electrophoresis of DNA from *Legionella pneumophila* isolates. The patterns of the 2 patients' isolates (**pt 1** and **pt 2**) and that from the fountain (**ftn**) are identical. For comparison, unmatching serogroup 1 isolates from a previous patient (**prev pt**) and an American Type Culture Collection specimen (**ATCC**) are shown.

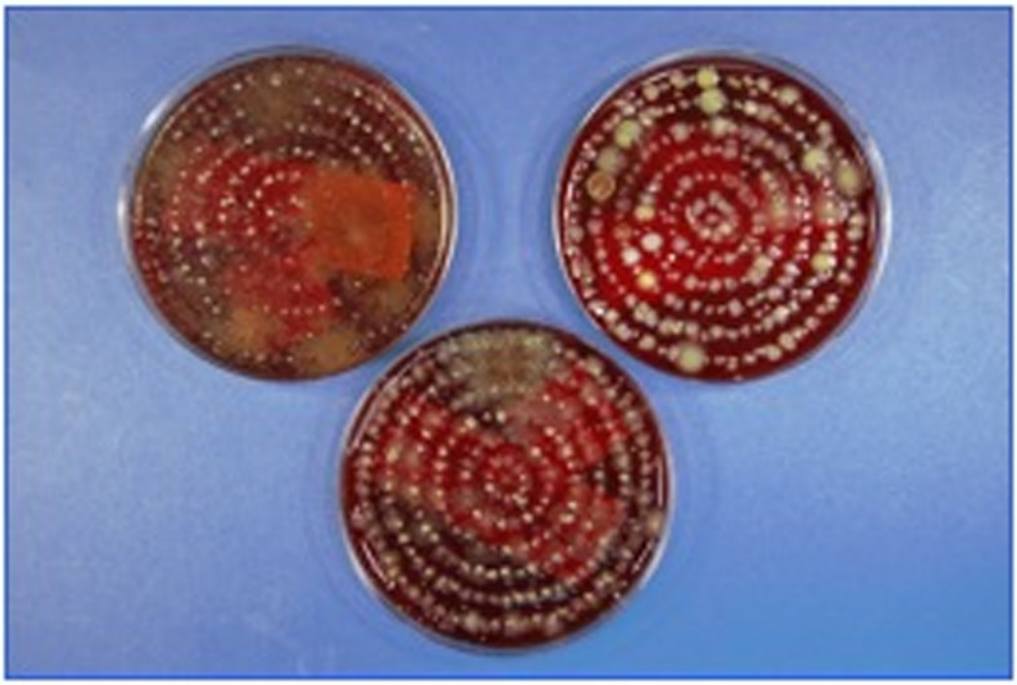

Photo courtesy of Daniel Fedorko, PhD

Figure 3.
Sheep blood agar plates used in air sampler approximately 0.6 m from the water feature. Plates had heavy growth of numerous bacterial isolates, but grew no molds.