Legionella Pneumonia due to Exposure to 24-hour Bath Water Contaminated by Legionella pneumophila Serogroup-5

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ABSTRACT

A 79-year-old man was admitted to hospital from his nursing home for treatment of pneumonia, but died 7 days after admission. Legionella pneumonia was diagnosed after isolation of Legionella pneumophila serogroup-5 from sputum culture. The environment of the nursing home was investigated; only water specimens from the 24-hour bath were positive by culture for Legionella pneumophila serogroup-5. Subsequent analysis by pulsed-field gel electrophoresis revealed an identical pattern in isolates from both sputum culture and 24 hour bath water culture. Among 123 inpatients and staff of the nursing home, 17 were found to be seropositive for Legionella pneumophila serogroup-5.

Key words: nursing home, pulsed-field gel electrophoresis, an outbreak of Legionella pneumonia

Introduction

In Western countries, Legionella pneumophila is, according to most studies, among the three most common causes of community-acquired pneumonia and it is the second-highest cause of severe pneumonia (1).

Bodies of water appear to be the natural habitat for Legionella pneumophila and man-made reservoirs serve as amplifiers for the organism. Outbreak investigators have shown that Legionella pneumonia can be transmitted by a variety of devices that produce a water aerosol, such as cooling towers, evaporative condensers, showers, faucets, humidifiers, whirlpool baths, and medication nebulizers.

The 24-hour bath,a bath with a constant circulation system, was commercially introduced to Japan in 1984 and by 2001 more than 1,500,000 systems had been sold for use in homes, public baths and other facilities.

Because Japanese people love to take baths or visit hot spring spas, and because Legionella pneumophila contamination of these waters has been reported (2, 3), such baths came under suspicion as being a potential source of Legionella infection. However, the incidence of Legionella pneumonia in Japan remains far lower than in Western countries (4, 5) and there are only a few cases of Legionella pneumonia in which the sources of infection were directly determined to be these waters (6).

We report here the first patient with Legionella pneumonia whose source of infection was determined to be 24-hour bath water contaminated by Legionella pneumophila serogroup-5, identified by means of pulsed-field gel electrophoresis.

Case Report

A 79-year-old man, who had a 10-year history of senile dementia and had been admitted to a nursing home 1 week previously, was transferred to hospital for treatment of pneumonia on May 15, 1998. He was thin and anemic, his body temperature was 37.2°C, blood pressure was 134/82 mmHg; pulse 80, respiration 30. Chest auscultation revealed crackles on the left lower lung field and wheezes on the anterior chest wall. His chest X-ray (Fig. 1) revealed bilateral pneumonia and right sided pleural effusion. Laboratory data on admission (Table 1) were: white blood cell count, 14,200/l; C-reactive protein, 16 mg/dl; serum Na, 133 mEq/l; PaO₂, 49.2 Torr; PaCO₂, 29.7 Torr.

Initially, we treated him with cefotiam (CTM) because Haemophilus influenzae-like bacteria were observed by gram staining of expectorated sputum. However, pneumonia progressed rapidly despite treatment with panipenem/betamipron and erythromycin. He died 7 days after admission. After his death, a positive diagnosis of Legionella pneumo-
nia was made by isolation of *Legionella pneumophila* serogroup-5 organisms from expectorated sputum culture. Other causative agents were not identified from sputum culture.

Environmental investigation

Water samples were collected from cooling towers, baths and 24-hour baths in the nursing home on May 27. Water samples were concentrated and cultured on WYO/TypeOne0 media using standard techniques to isolate Legionella species. Only water specimens from 24-hour baths were found to be positive by culture for Legionellae, and the species was identified as *Legionella pneumophila* serogroup-5. Subsequent analysis by pulsed-field gel electrophoresis revealed an identical pattern in isolates from both sputum culture and 24-hour bath water culture (Fig. 2). The patient had taken this 24-hour bath once. From these results, we concluded that the 24-hour bath was the source of infection.

### Table 1. Laboratory Data on Admission

<table>
<thead>
<tr>
<th>Hematology</th>
<th>Biochemistry</th>
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<tbody>
<tr>
<td>WBC 14,200/μl</td>
<td>ALT* 15 IU/l</td>
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<tr>
<td>Neu –Met 6%</td>
<td>AST* 10 IU/l</td>
</tr>
<tr>
<td>–St 21%</td>
<td>LDH 213 IU/l</td>
</tr>
<tr>
<td>–Seg 58%</td>
<td>T-bil 0.8 mg/dl</td>
</tr>
<tr>
<td>Lym 13%</td>
<td>TP 7 g/dl</td>
</tr>
<tr>
<td>Mono 2%</td>
<td>Alb 3.2 g/dl</td>
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<tr>
<td>RBC 382×10⁴/μl</td>
<td>BUN 21.3 mg/dl</td>
</tr>
<tr>
<td>Hb 11 g/dl</td>
<td>Crea 0.9 mg/dl</td>
</tr>
<tr>
<td>Hct 32.9%</td>
<td>Na 133 mEq/l</td>
</tr>
<tr>
<td>Plt 19.5×10⁴/μl</td>
<td>K 3.9 mEq/l</td>
</tr>
<tr>
<td>ESR 100 mm/h</td>
<td>Cl 99 mEq/l</td>
</tr>
<tr>
<td>CRP 16 mg/dl</td>
<td>Tcho 129 mg/dl</td>
</tr>
<tr>
<td></td>
<td>TG 59 mg/dl</td>
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<tr>
<td></td>
<td>Glu 110 mg/dl</td>
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Blood gas analysis (room air)

<table>
<thead>
<tr>
<th></th>
<th>Urinalysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH 7.507</td>
<td>protein +</td>
</tr>
<tr>
<td>PaCO₂ 29.7 Torr</td>
<td>sugar +</td>
</tr>
<tr>
<td>PaO₂ 49.2 Torr</td>
<td></td>
</tr>
</tbody>
</table>

*ALT: alanine transaminase, AST: aspartate transaminase.*

1: molecular weight marker
2: *Legionella pneumophila* serogroup 5 standard strain
3: *Legionella pneumophila* serogroup 5 isolated from the patient
4: *Legionella pneumophila* serogroup 5 isolated from environment A
5: *Legionella pneumophila* serogroup 5 isolated from environment B
6: molecular weight marker

**Figure 1.** Chest roentgenogram on admission. Bilateral pneumonia and right sided pleural effusion were observed.

**Figure 2.** Pulsed-field gel electrophoresis was performed using GenePath group 5 (Bio-Rad Laboratories, Hercules, CA). Briefly, DNA was extracted from overnight cultures grown at 37°C on BYE broth and digested with Sfi I overnight at 50°C according to the manufacturer’s instructions. Digested DNA was electrophoresed in 1% agarose gels for 20h with a ramped pulse time of 1 to 80s. DNA fragments were visualized by staining with 0.5 μg of ethidium bromide/ml.
Serological survey

A serological survey of inpatients and staff at the nursing home was then carried out. On November 1998, serum samples were collected from 80 inpatients and 43 staff and tested for antibodies against *Legionella pneumophila* serogroup-5 by the microplate agglutination test (7).

The distribution of antibody titers in all 123 samples is shown in Fig. 3. Upon analysis, 11 of 80 inpatients (13.8%) and 6 of 43 staff (14.0%) had titers higher than 1:128, the cut-off value for positivity of *Legionella pneumophila* serogroup-5 specific antibody. All serologically positive inpatients had taken the 24-hour bath and all serologically positive staff had helped inpatients taking the bath. Although all of these “serologically positive subjects” had been exposed to contaminated water, none of them had clinical symptoms of *Legionella* infection.

Discussion

The 24-hour bath is a continuously circulating system with filtering and sterilizing equipment. The 24-hour bath of the nursing home examined here had a system which used bacteria to decompose organic matter. In order to protect against bacteria, not chlorine but ozone was used for sterilization. This nursing home was opened in April 1998 and since that time the water of the 24-hour bath had not been changed until this case occurred. Previous investigations of whirlpool spa-associated outbreaks of Legionnaires’ disease have isolated Legionellae from sand filters in which concentrations of halogen-based biocides may have been too low (8). In the present case, the organic matter removal system is considered to have been a reservoir of *Legionella* pneumophila.

Although the 24-hour bath is widely used in Japan, the present case is the first that showed such baths to be the source of infection. Following the documentation of this case, the Ministry of Health, Labour and Welfare issued a manual for prevention of 24-hour-bath-associated *Legionella* infection; periodic sterilization of filters and the use of chlorine was recommended. The nursing home to which the present patient was admitted is now using chlorine to sterilize the 24-hour bath water and no cases of pneumonia have occurred since the introduction of this procedure.

Epidemiological studies in this nursing home revealed 17 persons (13.8%) with antibody titers greater than 1:128 and 11 persons (8.9%) with titers higher than 1:256. These results resemble those of Maesaki et al (9) who reported an outbreak of Legionnaires pneumonia in a nursing home. Attack rates in outbreaks of Legionella pneumonia are usually low [0.1%–5% of exposed persons develop clinical symptoms (10)] and the development of pneumonia was seen in only one person here. The low attack rate may be due to host factors or differences in exposure (10). However, especially in places such as nursing homes where many people are susceptible to microbes, strict management practices to reduce microbial contamination of 24-hour bath water are needed to prevent Legionella pneumonia which can sometimes cause severe disease (11).

*Legionella pneumophila* has been identified as the causative agent in 80–90% cases of Legionella pneumonia, and *Legionella pneumophila* serogroup-1 causes 50–70% of this pneumonia (11–14). However, strains of *Legionella pneumophila* other than serogroup-1 have also been reported to be the causative agents of Legionella pneumonia, the sources of infection with which seem to be the waters of hot spring spas (6, 15). The reason for this difference in causative agents is considered to be differences in bacterial distribution in the environment (3, 15, 16).

Although *Legionella pneumophila* serogroup-5 is rarely a causative agent of Legionella pneumonia (11, 17), serogroups-3,5 and 6 are reported to be dominant in 24-hour baths in Japan (3). Therefore, *Legionella pneumophila* serogroup-5 is considered likely to be one of the main causative agents of 24-hour bath-related Legionella pneumonia.

Chang et al (17) reported that 2 of 3 Legionella pneumonia cases caused by *Legionella pneumophila* serogroup-5 were successfully treated with intravenous erythromycin. On the other hand, age, male gender, nosocomial infection, immunosuppression, end-stage renal disease and cancer are associated with mortality due to Legionella (11). The reasons that the present patient died despite intravenous erythromycin is thought to be because he was elderly and poor nutrition was thought to have weakened his immune system.

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References


