Nontuberculous Mycobacterial Disease Following Hot Tub Exposure

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Nontuberculous mycobacteria (NTM) have been recognized as an important cause of disease in immunocompromised hosts. Pulmonary disease caused by NTM is increasingly recognized in previously healthy persons. Investigation of pulmonary disease affecting a family of five identified an indoor hot tub as the source of NTM-related disease.

Nontuberculous mycobacteria (NTM) are an important cause of disease in the United States, with the number of NTM isolates exceeding those of Mycobacterium tuberculosis (1). Pulmonary disease, the most commonly reported localized manifestation of NTM, is often associated with the M. avium complex (MAC) (2). Other NTM species, such as M. kansasii, M. fortuitum, M. xenopi, and M. abscessus, have also been associated with pulmonary disease (2,3). Although NTM-associated pulmonary disease has been described primarily among immunocompromised persons (4,5), it is being recognized with increasing frequency among those without predisposing conditions (2,6,7).

Unlike MTB, NTM are not known to be transmitted person to person. Most NTM have been isolated from water or soil (8-14). Species such as MAC are thermophilic (12), resistant to chemical germicides (14), and readily aerosolized (13). For several NTM species, environmental sources have been linked epidemiologically to cases of disease (15-20). In 1991, Burns investigated an outbreak of respiratory tract colonization in which epidemiologic and pulsed-field gel electrophoresis (PFGE) findings implicated a contaminated showerhead as the source of M. fortuitum (21). Subsequently, von Reyn used PFGE to link MAC infection in five AIDS patients to hot water sources in two hospitals (22).

Recently, Embil et al. (23) described five persons who became ill with pulmonary disease following exposure to hot tubs. MAC was isolated from all five patients and the two tubs. When MAC isolates were examined by multilocus enzyme electrophoresis (MEE), however, the hot tub and patient isolates had different MEE patterns. Kahana et al. (24) reported one patient diagnosed with MAC disease associated with a hot tub. In this case, the organisms isolated from the patient and the tub were identical by MEE.
involved the mid to lower lung. The patient was begun on a second course of prednisone and showed some improvement. A chest radiograph obtained on September 22, however, showed an interstitial lung process involving all areas, although both lungs appeared radiographically improved. Prednisone was discontinued on September 23 in anticipation of an open lung biopsy. Oxygen saturation (SaO₂) measurements before surgery on 4 liters of O₂ ranged from 88% to 92%.

On September 24, the patient had an open lung biopsy of the lingula and left lower lobe. The lingula showed moderate to severe granulomatous inflammation with AFB, numerous granulomas with focal caseation and necrosis, interstitial chronic inflammation, and mild and interstitial immature fibrosis with foci of foci. The left lower lobe of the lung showed moderate granulomatous inflammation, multiple granulomas with focal caseation and necrosis, and mild interstitial chronic inflammation and immature fibrosis. Aerobic tissue cultures showed rare gram-positive cocci. Stains and cultures for fungi and Legionella were negative, as were a shell vial assay and culture for cytomegalovirus. An intradermal test with 5 tuberculin units of purified protein derivative S (PPD) placed on September 24 was negative. Serologic HIV test results were also negative. A chest radiograph obtained September 25 showed bilateral hiliar consolidation consistent with atelectasis or pneumonia with some infiltrate in the upper lobes.

On September 25, the patient was begun on oral isoniazid, 300 mg; rifampin, 600 mg; ethambutol, 400 mg; and pyrazinamide, 500 mg daily for suspected miliary tuberculosis. This regimen was discontinued 7 days later.

On subsequent evaluation at National Jewish Hospital, who noted the possibility of NTM-related disease secondary to hot tub exposure. Approximately a year earlier, the family had installed a hot tub in an enclosed sunroom next to the kitchen. The source of water for the tub was surface water from the Boulder municipal system, transported via tanker truck. Drinking and bathing water come from an alluvial aquifer well shared with several neighbors.

The hot tub water was changed only two or three times from January to October. The tub was equipped with an ozonator. On occasion a chlorine/bromine float or a cup of bleach would be added just before the tub was used. Disinfectant levels or pH were not checked.

Patient 1 used the hot tub rarely, most recently once in June and a second time in July. Because the tub water irritated her skin, she showered immediately after using the tub. However, when one of her sons was in the tub, she generally stood nearby. The 12-year-old, Patient 4, was the most frequent user. The three children often entered the tub after having been outside, without having showered first. Patients involved in the investigation of the possibility of NTM-related disease secondary to hot tub exposure.

### Table: Laboratory and pulmonary function test results for five patients with nontuberculous Mycobacterium infection

<table>
<thead>
<tr>
<th>Patient</th>
<th>AFB</th>
<th>MAC</th>
<th>FEV₁ 6 mo</th>
<th>FVC</th>
<th>DLCO/VA</th>
<th>RV</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>- smear</td>
<td>+ culture</td>
<td>1.40 (42%)</td>
<td>2.47 (75%)</td>
<td>1.86 (44%)</td>
<td>3.25 (80%)</td>
</tr>
<tr>
<td>2</td>
<td>+ smear</td>
<td>+ culture</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>3</td>
<td>- smear</td>
<td>+ culture</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>4</td>
<td>+ smear, + culture</td>
<td>- probe</td>
<td>1.98 (61%)</td>
<td>2.63 (76%)</td>
<td>2.57 (68%)</td>
<td>3.41 (84%)</td>
</tr>
<tr>
<td>5</td>
<td>- smear</td>
<td>- culture</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

AFB = acid-fast bacilli; MAC = Mycobacterium avium complex; FEV₁ = forced expiratory volume; FVC = forced vital capacity; DLCO/VA = diffusing capacity of the lung for carbon monoxide; RV = residual volume; – = not done.
1 and 4 had the greatest exposure to the hot tub aerosols. In retrospect, they described a clear relationship between hot tub exposure and worsening of symptoms, i.e., recurrence of night sweats, chills, and fever.

Following identification of MAC and M. fortuitum from clinical specimens (Table) and further consultation, Patients 1 and 4 were begun on a regimen of rifampin, ethambutol, amikacin, clarithromycin, ciprofloxacin, and prednisone. Patients 2, 3, and 5 were treated with clarithromycin and ciprofloxacin. After 6 months, pulmonary function tests for Patients 1 and 4 had improved (Table), signs and symptoms had resolved, and chest radiographs were normal for all family members.

The results of sputum evaluation on smear and culture for AFB are summarized (Table). Patient 4 was smear and culture positive for AFB, but negative on probe for MTB or MAC. The organism was subsequently identified as M. fortuitum.

Patient and water isolates were initially identified as MAC and typed by MEE, with identical enzyme profiles (25). Restriction fragment-length polymorphism (RFLP) analysis with an insertion sequence specific for M. avium (IS 1245) (26) confirmed that all isolates were the identical strain of M. avium (Figure). Isolation of M. fortuitum from this hot tub has been described (27).

**Conclusions**

NTM organisms isolated from the hot tub are likely responsible for this family's illness for the following reasons: exposure to the hot tub was temporally related to onset of symptoms; MAC was isolated from the lung biopsy and sputum of one patient and the sputum of two others, as well as from the hot tub; and MAC isolates from patient specimens and the hot tub were identical by RFLP. In addition, M. fortuitum was isolated from both the hot tub and a fourth hot tub-exposed person.

The source of the MAC and M. fortuitum is unclear. Our inability to isolate either organism from samples from the tanker truck used to supply water for the hot tub does not rule this out as a source. NTM have been isolated from municipal water supplies in the past (22). Alternatively, the users may have introduced the organisms, as the children often used the tub without showering first.

Proliferation of these organisms in a hot tub is not surprising, as both MAC and M. fortuitum are thermophilic (12). Moreover, at temperatures >84°F, chlorine loses much of its efficacy as a disinfectant (15).

Controversy exists as to whether persons with pulmonary disease secondary to NTM are experiencing a hypersensitivity reaction to the organisms or symptoms secondary to true infection (28,29). Murphy concludes that in the presence of dyspnea, nodular infiltrates seen on CT, response to steroids, and absence of predisposing factors such as chronic lung disease, a patient with MAC-related lung disease has hypersensitivity pneumonitis. Pathologic findings, including palisaded and multinucleated histiocytes and granulomatous inflammation, however, suggest infection (28). In a recent case presentation, symptoms and radiographic findings in a patient from whose lung tissue MAC was cultured are consistent with both the diagnoses of hypersensitivity pneumonitis and atypical mycobacterial infection, a conclusion substantiated by pathologic findings (29). In cases evaluated at National Jewish Medical and Research Center, most patients required treatment with both steroids and antimycobacterial medications (30). This experience suggests that NTM disease represents a spectrum of disease with components of both hypersensitivity pneumonitis and infection.

Our cases had characteristics of both hypersensitivity pneumonitis and true infection. The short interval between hot tub use and exacerbation of symptoms and the patchy ground-glass appearance of the lungs, with centrilobular nodules on CT, suggest hypersensitivity pneumonitis (31). The granulomas seen on pathologic examination and the response to treatment with antimycobacterial medications, however, suggest true infection. The temporary improvement in Patient 1's condition after she received prednisone may represent either appropriate treatment of hypersensitivity pneumonitis or a decrease in granulomatous inflammation in the bronchioles, secondary to infection (28).

Little data exist to explain the mechanism of disease caused by NTM in healthy persons. Exposure to sufficiently large and repeated inocula of the organism in droplets of readily respirable size appears to be sufficient to overwhelm normal host defenses.

Hot tubs should be maintained according to manufacturers' recommendations, which include both frequent water changes and adequate use of disinfectants. In addition, placing a hot tub in an enclosed environment should be strongly discouraged. Patients with atypical pneumonia should be questioned about similar illnesses among family members and others who have had similar exposures, including exposure to a hot tub. As hot tubs become increasingly popular (pers. comm., John J. Cergol, Jr.), hot tub-related illness associated with NTM may become an emerging infectious disease challenge.

**Acknowledgment**

We thank Sally G. Houser for preparation of this manuscript.

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References


