Pulmonary Illness Associated With Exposure to Mycobacterium-avium Complex in Hot Tub Water*

Hypersensitivity Pneumonitis or Infection?

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Background: Mycobacterium avium complex is common in water. When aerosolized, it is frequently inhaled but rarely causes illness in healthy people. Hypersensitivity pneumonitis to inhaled aerosols has been described; these aerosols are from several sources of water. The pneumonitis forms collectively known as humidifier lung; the responsible agent in the water remains uncertain.

Purpose: To report five cases of respiratory illness in healthy subjects using hot tubs contaminated with M avium complex.

Design: Descriptive case reports.

Setting: Consultations in two teaching hospitals.

Patients: Five healthy people developed respiratory illnesses characterized by bronchitis, fever, and “flu-like” symptoms after using a hot tub. Acute exacerbations of their illness developed within hours of heavy use of the hot tubs.

Investigations: A chest radiograph and sputum culture in all, BAL in one, CT scan and lung biopsy in another were performed. Culture of the water of the two hot tubs also was done.

Results: Chest radiographs showed interstitial infiltrates or a miliary nodular pattern. Cultures of all sputum samples, the lung biopsy specimens, lung lavage and water samples were positive for M avium complex. The lung biopsy specimen revealed noncaseating granulomas. All patients recovered with no treatment for M avium complex.

Conclusion: We conclude that the M avium complex in the water was responsible for the pulmonary illnesses. The symptoms and the results of investigations are more suggestive of a hypersensitivity pneumonitis than of an infection, but no serologic proof of an immunologic reaction to the M avium complex or water was obtained.

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Key words: atypical pneumonia; hot tub; water; hypersensitivity pneumonitis; Mycobacterium avium complex

The mystery of Mycobacterium avium complex’s role in lung disease is exemplified by a recent clinicopathologic conference.¹ The organism is opportunistic and infects healthy individuals, but rarely causes disease.² We wish to add a piece to the puzzle of diseases associated with this organism and their relationship to potable water.³ The report will also add a possible agent for humidifier lung.⁴ Hypersensitivity pneumonitis (extrinsic allergic alveolitis), following exposure to water. We report a case, and a cluster of four similar cases, of a pulmonary illness in subjects who used hot tubs contaminated with M avium complex. Hot tubs are large baths, often shared by several people. Hot water is agitated by powerful jets of air or of water that produce bubbles and hence aerosols. The growth of M avium complex is favored by hot water.⁵

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REPORT OF CASES

Case 1

A 28-year-old healthy plumber used his indoor hot tub for 1 h daily. It was filled with well water in October and emptied in May without water changes. The temperature of the tub water was 37 to 39°C and the pH level was 7 to 8. In the second year of hot tub use, he developed episodes of a “flu-like” illness consisting of fever (38°C), chills, malaise, and headaches. He was empirically treated for bronchitis and chose to increase his hot tub use to alleviate symptoms. He became progressively dyspneic and lost weight (7 kg). At the time of admission to the hospital, auscultation revealed bilateral pulmonary crepitations. He was hypoxemic (PaO₂, 45 mm Hg). The chest radiograph showed patchy infiltrates in the right lower lobe. Because the condition was diagnosed as an atypical pneumonia, he was treated with erythromycin; he recovered in 1 week and returned home. He reused his hot tub and suffered a relapse. This time the chest radiograph showed bilateral infiltrates and a CT scan (Fig 1), with 10 and 1.5-mm resolution slices sampled, revealed a patchy ground-glass infiltrate affecting both central and peripheral areas of the lung accompanied by ill-defined centrilobular nodules. The intervening areas were normal. Due to worsening of his condition, an

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open-lung biopsy was performed, this exhibited (Fig 2) interstitial granulomas containing histiocytes, lymphocytes, epithelioid cells, and some giant cells. There was no necrosis or fibrosis. Occasional terminal bronchioles had a similar infiltrate, with partial destruction of the wall (Fig 3) and occasional bronchiolitis obliterans. There was no vasculitis. Mycobacteria rarely were seen. The biopsy specimen was considered to show features compatible with hypersensitivity pneumonitis. Lung culture grew M avium complex. Serum tests for HIV were negative and all blood and sputum cultures were negative for bacteria. A 5TU tuberculin test was negative with no anergy to mixed trichophyton and Can dida albicans (1:100 supplied Bencard; Mississauga, Canada). Treatment was given for 3 days with antituberculous drugs until the M avium complex was identified. Because this case resembled a similar case seen about 5 years previously, the hot tub water was examined and found to contain a heavy growth of M avium complex as well as Pseudomonas sp, Penicillium sp, and Scopulariopsis sp. No further treatment was given, and the patient recovered fully within a month. Lung function, when he was recovering, showed a mild airflow obstruction with a low gas (CO) transfer. The hot tub was sold, and he has been well for 2 years.

Case 2

Eight years previously, a 48-year-old surgeon had used a hot tub daily for 6 years. The water was changed twice a year using chlorinated city water obtained from wells. The water temperature was 37 to 42°C. The hot tub was in the room he used as a study. For 4 months, he noticed a dry cough and slight dyspnea which slowly worsened. For this bronchitis, he was given erythromycin for a month without improvement. One day, he cleaned the dirty filter of the tub and within a few hours developed severe dyspnea. Auscultation detected pulmonary crepitations. His chest radiograph showed bilateral patchy nodular infiltrates. He was considered to have acute asthma and pneumonia. He was hypoxemic (PaO₂ 65 mm Hg). He discussed his illness with a colleague who suspected humidifier lung, but tests of his serum revealed no precipitins against humidifier organisms, nor were they grown in the water (personal communication; J. Fink; Medical College of Wisconsin). Humidifier fever was also considered, but the endotoxin level was low (<1.25 U/mL) in the water. All blood and sputum cultures were negative for bacteria, except that Mycobacteria were seen in his sputum. His tuberculin test 5TU was negative. A BAL yielded 500×10⁶ cells/L, 74% of which were T4; 6%, T8, and 1%, B lymphocytes. M avium complex was cultured from the lavage fluid. His clinical picture resembled acute allergic alveolitis rather than tuberculosis. Knowing that water can contain Mycobacteria, the physician examined the filter of the hot tub, and M avium complex was cultured from a sample removed from it. The patient was given no antituberculous drugs and recovered spontaneously over the next few weeks. He converted his hot tub into an indoor garden and never developed such an illness again.

Cases 3-5

While patient 2 was being evaluated, two of his daughters, aged 12 and 16 years, and their friend, aged 16, used the hot tub. All three developed cough, dyspnea, fever, and chills within hours of exposure. Over the next week, the two 16-year-olds were tired, had cough with clear phlegm, and had wheezing on exertion. The three girls had widespread miliary nodular changes evidenced on an x-ray film. Once M avium had been detected in the father’s sputum, the three girls were tested. M avium complex was isolated from the sputum of one and in the gastric lavage of another. The 12-year-old, who spent the least time in the pool, improved quickly. The other two took several weeks to recover. None were given treatment. The wife and the youngest daughter of patient 2 had not used the hot tub and were well. All the family had negative tuberculin tests. Patient 2 and the two 16-year-olds had a restrictive pattern of lung function with a low (CO) gas transfer. Eight years later, all are well with normal lung function and normal chest radiographs.
The M avium complex cultured from the water of the two hot tubs (cases 1 and 2), the lung biopsy isolate from patient 1, and the sputum from patients 2 to 5 were sent to the Center for Disease Control and Prevention, Atlanta, for typing by seroagglutination and multiple enzyme electrophoresis. All M avium complex isolates from patients were found to be M avium serotype 8 with identical enzyme patterns. The two water isolates failed to serotype and had different enzyme patterns than those from the patients.

**DISCUSSION**

We believe that the temporal relationship between use of the hot tubs, the presence of the M avium complex in the water, and the isolation of M avium complex from the lung biopsy specimen and BAL specimen as well as from the sputum sample establish that this organism was responsible for the illnesses reported. Though the two isolates from the water did not match those from the patients, the hot tub water may have contained a mixed population of M avium complex, and the specific causal organism might have been detected with more extensive sampling and colony picking. The water of the tub in the first case also grew Pseudomonas sp, Penicillium sp, and Scopulariopsis sp; there was no evidence of pulmonary infection by these organisms by culture. Extensive investigations for other infecting organisms by culture and serologic testing identified nothing.

The whirlpool action of a hot tub would have easily aerosolized the contaminated water. Studying the James River, Gruft et al and Wendt et al have shown that M avium complex is common in natural sea and fresh water. The organism can be concentrated in hot water systems including hospitals. This organism is aerosolized when bubbles form in water and thus can be inhaled. Having entered the lung, infection can occur. Pulmonary disease with M avium complex usually occurs in people with damaged lungs, such as those with COPD, bronchiectasis, pneumoconiosis, or AIDS. When disease develops, it has the reputation of producing serious persistent lesions. Teirstein et al reviewed 487 patients with pulmonary disease from whom M avium complex was obtained from the lungs; 244 were stated to have true infection because their pulmonary disease followed four patterns: pulmonary nodules, bronchiectasis, cavitary lung disease, or diffuse infiltrates in immunocompromised individuals. The other 243 patients were stated to have false-positive cultures, that is, the cultures were positive, but the physicians could not identify these patterns of disease in the patients. No information is given as to what illness prompted the culture of the sputum in these 243 people, and the authors may have overlooked other reactions to M avium complex.

We are unsure whether the illnesses we observed should be regarded as a transient infection or a hypersensitivity response. The illness we reported was different from that in the series of 21 healthy people infected by M avium complex reported by Prince et al. These researchers observed bronchitis and nodular infiltrates on the chest radiograph but these conditions slowly progressed. In addition, lung biopsy specimens in the study by Prince et al revealed caseating granulomas. Moreover, treatment with antituberculous drugs was needed to halt the disease, relapse was common, and progression to death occurred in some. In the clinicopathologic case report, the clinician thought the patient had hypersensitivity pneumonitis as judged by the clinical picture, but the lung biopsy showed noncaseating granulomas surrounding terminal bronchioles, and M avium was observed in the biopsy specimen and was cultured from it. The source of the infection and why this healthy young man caught it was not determined, and the consulting physician was left unable to accept the diagnosis of M avium complex infection.

Humidifier lung is the generic name for a form of hypersensitivity pneumonitis associated with the inhalation of contaminated water from air-conditioning systems and from domestic, office, and industrial humidifiers. The disease also has been reported in showers, at a swimming pool, and in a sauna. Mycobacteria have not been implicated in these cases, but have been sought in a study of hot water fever. The clinical picture we observed resembled that described in an epidemic of hypersensitivity pneumonitis attributed to tap water in Finland. We favor that our patients had hypersensitivity pneumonitis based on the short time between the exacerbation of the symptoms and the hot tub use, which seemed too quick for infection with mycobacteria. Above all, the spontaneous recovery of all patients with cessation of hot tub use supports a hypersensitivity illness rather than an infection. The investigations also were similar to those reported in the outbreak of hypersensitivity pneumonitis at the swimming pool because of the patchy ground-glass appearance of the lungs with centrilobular nodules that was shown on the CT scan of the lungs. Although increased T8 cells in BAL is the usual finding with hypersensitivity pneumonitis, an excess of T4 cells was also found in the cases at the swimming pool. Most convincing was the lung biopsy which showed changes associated with hypersensitivity pneumonitis: noncaseating granulomas and some bronchiolitis. Unfortunately, we were unable to produce a suitable antigen from the M avium complex that might have been used to detect evidence of sensitization, nor did we simply look for precipitins in the patients’ sera to crude extracts of the hot tub water.

A number of organisms from cold water have been implicated as the provocative antigens in humidifier lung. They include thermophilic Actinomyces, Sphaerosplices, Penicillium sp, protozoa, and Klebsiella oxytoxca. In the cases involving hot water in the sauna, Pululalia was blamed, but for bath water, organisms have not been identified although endotoxin was suggested as the cause for fever in the latter cases. The Penicillium sp cultured from the water in case 1 was not ruled out as a possible cause for the disease. Infections have been recognized from hot tubs specifically. P aeruginosa has produced folliculitis and pneumonia, while soft tissue infection with M avium has been reported in a user of a hot tub.

We recommend that all patients with atypical pneumonitis that defies easy diagnosis should be questioned about hot tub use. It has been suggested that for those infected with HIV, baths would be safer than showers. From our experience, we caution against hot tub use by HIV-infected patients and wonder if the tubs of communal bath houses also are a risk. The patients we describe here had neglected to follow the manufacturer’s instructions to replace the water.
and change the filters. This may be all that is necessary to prevent the build up of M avium complex in hot tubs. M avium complex is resistant to chlorination and so it is found in domestic water. The high chlorine concentrations needed for sterilization may be unpleasant for hot tub use. Superheating the water, if possible, to 70°C for up to an hour may help. If our findings prove to occur more frequently in hot tubs, then a study of how to control the growth of M avium complex must be done.

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REFERENCES
10 Rosenzweig DY. Pulmonary nontuberculous mycobacterial disease due to Mycobacterium intracellulare: clinical features and course in 100 consecutive cases. Chest 1979; 75:115-19

Another Hot Tub Hazard*

**Toxicity Secondary to Bromine and Hydrobromic Acid Exposure**

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We describe the clinical course of two patients who developed acute pneumonitis followed by reactive