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Hypersensitivity Pneumonitis from Ordinary Residential Exposures

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A previously healthy woman developed hypersensitivity pneumonitis of such severity that she required chronic systemic corticosteroid therapy for symptom control. Detailed investigation of her workplace and home environments revealed fungi in her typical suburban home, to which she had specific serum precipitating antibodies. Efforts to remove mold from the home were unsuccessful in relieving symptoms, and moving to another residence was the only intervention that allowed her to be withdrawn from corticosteroid therapy. Hypersensitivity pneumonitis is commonly associated with occupational or avocational exposures, such as moldy hay in farmers or bird antigen in bird breeders. We propose that hypersensitivity pneumonitis may occur in North America, as it does in Japan, from domestic exposures alone. *Key words*: *Aureobasidium pullulans*, extrinsic allergic alveolitis, fungal diseases, humidifier fever, hypersensitivity pneumonitis, indoor air quality, *Saccharopolyspora rectivirgula*. *Environ Health Perspect* 109:979–981 (2001). [Online 12 September 2001]
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Case Presentation

A 50-year-old, nonsmoking automobile parts assembly worker presented with summertime cough for 8 years, and breathing difficulty with exercise for several months. She denied fever. The patient's chest X ray was interpreted as being within normal limits (Figure 1). She was initially treated by her primary physician for presumed asthma with an inhaled beta agonist, which brought no relief. The patient was then treated with a brief course of oral prednisone, which brought symptomatic relief. She was referred to a pulmonologist, who heard crackles on her chest exam, but detected no palpable lymphadenopathy. Spirometry on 15 November 2000 was within normal limits (Table 1), but oxygen desaturation occurred with 2 min of brisk walking. Two weeks later (29 November 2000) spirometry showed a 600 mL loss in forced vital capacity (FVC) to 73% predicted (Table 1). High-resolution computed tomography scan of the chest showed ground glass opacities bilaterally and peripherally (Figure 2). Bronchoalveolar lavage fluid contained 60% lymphocytes (normal ≤ 20%), 30% macrophages, and 10% polymorphonuclear leukocytes. A trans-bronchial biopsy was nondiagnostic due to inadequate tissue. Serum precipitating antibodies were measured on a standard, commercially available hypersensitivity pneumonitis panel of 10 antibodies to 10 common antigens. Serum precipitating antibodies were present to *Aureobasidium pullulans* and *Saccharopolyspora rectivirgula*. Symptoms had been most troublesome during hot summer months.

In her job, the patient assembled small parts using a petroleum distillate lubricant applied from a small squeeze bottle. She did not work with metal working fluids herself, but metal working fluids were used near her work area. A sample of the petroleum metal working fluid from the area closest to her work area was cultured for fungi and thermophilic actinomycetes, and yielded < 1 colony-forming unit (CFU)/mL fluid.

The patient's home was heated by oil forced air and cooled by a window-mounted air conditioner; she had one dog and one cat, but no birds. The unfinished basement of her house had evidence of mold growth on the cement wall (Figure 3). Thick fiberglass insulation, mounted on plastic sheeting, covered all four walls of the basement (Figure 4). The patient reported having a major water leak from the second floor, along a wall surface, to the floors below 2 years earlier, but she noted no water damage to carpets. There were no sources of water aerosol other than faucets and a shower head. Several months before her diagnosis, she had activated 30–40 aerosol cans of insecticide (each containing 71 g 1% pyrethrins and permethrins) indoors because of fleas on her pet dog and cat. She vacated the house for the recommended 30 min and did not note worsening respiratory symptoms with use of this insecticide.

Water from the basement sump, fiberglass insulation from the basement, and carpeting from the living room were cultured and examined microscopically. Fiberglass produced 3.5×10^5 CFU fungi/g, identified as *Aureobasidium pullulans*; 4.4×10^4 CFU/g *Humicola* species; and 1.0×10^3 CFU/g of material identified as thermoactinomycetes with morphology similar to *Sacharopolyspora rectivirgula*. Carpet produced 6.0×10^3 CFU/g *Aureobasidium pullulans*, *Curvularia* species, and *Humicola* species.

After the initial 1 week of 20 mg prednisone bid (twice per day), the patient's symptoms had completely subsided, her lung crackles had cleared, and her diffusing capacity had increased from 45% predicted to 71% predicted (6 December 2000). The prednisone dose was then reduced. The patient remained asymptomatic with normal spirometry and continued to work as before. However, she began to suffer central nervous system effects of the prednisone, which was then discontinued. She traveled to Florida for 1 week. While she was away from her home and job, she felt well. On returning, the patient's spirometry was normal and she had no exercise-induced hypoxemia. After not taking prednisone for 5 weeks and resuming her usual home and work environments for over 4 weeks, the patient's dyspnea on exertion gradually returned, her FEV_1 and FVC fell, and her O_2 saturation decreased to 87% with exercise (Table 1). At

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that time, all fiberglass from her basement was removed and the carpets were cleaned. The patient's condition improved rapidly with reinstitution of 20 mg prednisone daily. However, when the prednisone dose was tapered, she again became symptomatic.

The patient was maintained on prednisone until she sold her home and moved to a new residence in June 2000, while maintaining her previous employment. Prednisone was again discontinued and she remained asymptomatic. Subsequent spirometry was within normal limits, although diffusing capacity remained abnormally low (Table 1.)

Discussion

Hypersensitivity pneumonitis may initially be clinically mistaken for acute pneumonia, asthma (as in this patient), or other forms of interstitial lung disease. Diagnostic criteria that have been proposed for clinical use include history, physical examination indicating interstitial lung disease, consistent radiograph, exposure to a recognized cause of this disease, and antibody to that antigen (*1*). Preventing progression of this patient's hypersensitivity pneumonitis required identification and removal of the source of antigens in the breathing air of her work or home environment. Although she worked in an industry where outbreaks of hypersensitivity pneumonitis associated with microbial growth in water-based metal working fluids (*2*) continue to be reported, sampling potential sources of aerosolized antigen at work and at home identified basement fiberglass insulation and carpeting in the living area of the home as reservoirs of the two microorganisms to which she had serum-precipitating antibodies. Such precipitating antibodies are evidence of exposure, although not necessarily indicating a causative relationship in hypersensitivity pneumonitis. An additional possible contributing factor in her home was the use of a pyrethrin/permethrin pesticide aerosol. These substances are widely used as relatively nontoxic insecticides in industry and consumer products, but they have been associated with hypersensitivity pneumonitis in two case reports (*3*).

Respiratory symptoms have been associated with reported visible mold, water damage, and dampness in a large Canadian survey (*4*). Respiratory symptoms have also been associated with cases of hypersensitivity pneumonitis associated with microorganism-containing aerosols generated by ultrasonic nebulizers, humidifiers, and air conditioners, and in one case with exposure to a moldy tapestry near the head of the bed (*5*). Yet few, if any, cases of hypersensitivity pneumonitis have been reported in North America from growth of microorganisms in normal building materials in the absence of an appliance generating an aerosol of microorganisms. An unusual recent case report by Wright et al. (*6*) demonstrated the occurrence of hypersensitivity pneumonitis caused by exposure to spores of a fungus growing in the basement of a California residence after unusually wet weather. The causal association was demonstrated by correlating serum-precipitating antibodies with airborne mushroom spores of *Pezizia domiciliana*, a small mushroom, growing in the basement after an unusually rainy season. In contrast, hypersensitivity pneumonitis from routine domestic exposures has been well described in other countries. The endemic Japanese summer-type hypersensitivity pneumonitis has been commonly associated with domestic exposure to *Trichosporon cutaneum* or *Cryptococcus albidus* (*7*), fungi that grow in rotting structural wood or wet tatami mats in residences (*8*). This kind of hypersensitivity pneumonitis has also been reported in South African residences (*9*).

In the present case, the excessive aerosolization of pyrethrin/permethrin insecticide in the home may have contributed to pulmonary inflammation, but this cannot explain the patient's chronic disease because

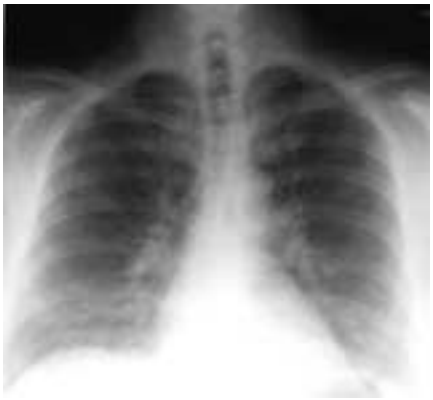

Figure 1. Chest X ray of the patient taken at time of first evaluation.

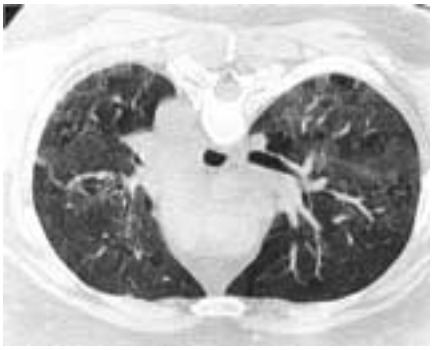

Figure 2. High resolution computed tomogram of the patient's chest shows "ground glass opacities" bilaterally, a finding suggestive of an active inflammatory process in the lung tissue.

Figure 3. Wall of the unfinished basement of the patient's home, with evidence of mold growth near the junction of the wall and floor.

Table 1. Laboratory data.

Date	FEV_1	FVC	DLCO	O_2 Saturation (%)		Comments
				Rest	Exercise	
15 Nov 1999	2.73 (95)	3.31 (87)	ND	95	85	Initial pulmonary evaluation
29 Nov 1999	2.38 (82)	2.76 (73)	45	ND	ND	Prednisone started
6 Dec 1999	3.27 (113)	3.87 (102)	71	ND	ND	Prednisone taper begins
3 Jan 2000	3.30 (114)	4.09 (108)	ND	ND	ND	Prednisone 10 mg bid
17 Jan 2000	3.19 (111)	3.89 (103)	ND	95	92	asymptomatic off prednisone
18 Feb 2000	3.10 (108)	3.63 (96)	ND	95	87	Symptoms return; prednisone restarted
6 Mar 2000	3.19 (111)	3.70 (98)	64	97	91	Symptoms improved; prednisone tapered
3 Apr 2000	2.94 (102)	3.62 (96)	63	ND	ND	Prednisone 10mg/day
22 May 2000	3.14 (109)	3.67 (97)	ND	ND	ND	Asymptomatic: prednisone 10 mg/day
10 Jul 2000	2.87 (101)	3.48 (92)	60	95	92	Asymptomatic
25 Sep 2000	2.89 (101)	3.50 (93)	60	ND	ND	Asymptomatic
7 Nov 2000	3.05 (107)	3.61 (96)	64	ND	ND	Asymptomatic
24 Jan 2001	3.09 (108)	3.60 (96)	62	95	92	Asymptomatic

Abbreviations: DLCO, diffusing capacity for carbon monoxide (percent predicted); FEV_1, forced expiratory volume in 1 sec in liters (percent predicted); FVC, forced vital capacity in liters (percent predicted); ND, Not done.

her clinical disease recurrences occurred many months after the last insecticide application. Review of her home suggested that ongoing exposures to mold and thermophilic bacteria continued to stimulate a pulmonary immunologic response. Similarly, although hypersensitivity pneumonitis has been associated with growth in air conditioners, this patient's disease was active during winter months when the air conditioner was off. The two microorganisms identified to which the patient had serum-precipitating antibodies are probably endemic in the local environment and may grow profusely when an appropriate reservoir is available. Clinically, this patient's course followed a chronic pattern, without acute episodes of fever and dyspnea, but rather with gradual exacerbations and remissions associated with exposure to or removal from the home environment.

The microorganisms to which the patient was exposed and had precipitating antibodies have been well described in workplace outbreaks of hypersensitivity pneumonitis or "humidifier fever," often due to overgrowth in industrial-sized humidification or air-conditioning systems. Thirteen years earlier, an industrial outbreak of 115 cases of hypersensitivity pneumonitis due to *Aureobasidium pullulans* growing in the water tanks of an air-conditioning system occurred in an industrial facility located only a few miles from the patient's home (*10*). The prevalence of this microorganism as part of the normal microbiota in homes in this community is unknown. The other organism found in her home to which she had serum-precipitating antibodies, *Saccaropolyspora rectivirgula* (formerly known as *Micropolyspora faeni*), is a common cause of hypersensitivity pneumonitis in dairy farmers. The occurrence of such a case in a rather typical home environment suggests that hypersensitivity pneumonitis from home exposures may occur more frequently than was previously suspected, although the history of a large interior water leak in the patient's home 2 years earlier may have led to abundant growth of organisms on interior materials. Symptoms persisted with removal of basement fiberglass and first floor carpeting, suggesting a reservoir of antigen in other areas of the home.

Figure 4. Commercial fiberglass, adherred on one side to plastic sheeting, was applied loosely to the basement wall of the patient's home for insulation. We found *Aureobasidium pullulans*, 4.4×10^4 CFU/g, and thermoactinomycetes with morphology similar to *Saccharopolyspora rectivirgula*, 1×10^3 CFU/g, growing on the fiberglass. Serum-precipitating antibodies to these microorganisms were identified in the patient's serum.

The presence of serum-precipitating antibodies is evidence of prior exposure and antibody response to a substance, but does not confirm whether the disease was caused by the material. In this case, it was helpful in making recommendations about major changes in environmental exposures. Commercial laboratories often test a panel of 10 substances that commonly cause hypersensitivity pneumonitis, but because over 50 causative substances have been identified, commercial panels may be read as "negative" in patients with this condition. The choice of precipitins to be assayed may be guided by knowledge or hypotheses of causative substances in the patient's environment.

Conclusions

Hypersensitivity pneumonitis (extrinsic allergic alveolitis) has now been associated with over 50 inhaled environmental substances (*11*). Most are biological materials such as fungi, bacteria, and animal proteins, while a few industrial chemicals have been found to cause this immunologic lung disease. Since the first clinical description in 1932, the largest number of case series have been described in dairy farmers exposed to microorganisms growing in hay and in pigeon breeders as well as other bird fanciers.

Case reports, case series, and descriptions of occupational outbreaks in North America and Europe have described disease in specific vocations or avocations, but only occasionally with exposures in the home. In North America, such cases from domestic exposure have been associated with an unusual source of a microbial aerosol, such as a humidifier or air-conditioning device. For this patient, moving to a new residence was the difficult but ultimately successful intervention in preventing the recurrence of disease and allowing the discontinuation of corticosteroid medication.

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