Case Report

Acute Eosinophilic Pneumonia in a New York City Firefighter Exposed to World Trade Center Dust

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We report a sentinel case of acute eosinophilic pneumonia in a firefighter exposed to high concentrations of World Trade Center dust during the rescue effort from September 11 to 24. The firefighter presented with a Pa_{O_2} of 53 mm Hg and responded to oxygen and corticosteroids. Computed tomography scan showed patchy ground glass density, thickened bronchial walls, and bilateral pleural effusions. Bronchoalveolar lavage recovered 70% eosinophils, with only 1% eosinophils in peripheral blood. Eosinophils were not degranulated and increased levels of interleukin-5 were measured in bronchoalveolar lavage and serum. Mineralogic analysis counted 305 commercial asbestos fibers/10^6 macrophages including those with high aspect ratios, and significant quantities of fly ash and degraded fibrous glass. Acute eosinophilic pneumonia is a rare consequence of acute high dust exposure. World Trade Center dust consists of large particle–size silicates, but fly ash and asbestos fibers may be found in bronchoalveolar lavage cells.

Keywords: asbestos; eosinophil; firefighter

Acute eosinophilic pneumonia has been described as an acute febrile illness with severe hypoxemia, diffuse pulmonary infiltrates, and an increase in bronchoalveolar lavage eosinophils. There is also no evidence of infection, no history of asthma or atopic illness, and complete resolution of all abnormalities after treatment with corticosteroids (1). It is a reversible cause of noninfectious respiratory failure (1–3). The condition is idiopathic, but there have been tantalizing clues that point toward environmental dust exposure. Badesch and coworkers reported a patient engaged in bicycle motocross who had participated in a race in dusty conditions on the day his symptoms began (4). Four patients reported by Pope-Harman and colleagues had been involved in unusual outdoor activities within days before the onset of symptoms (cave exploration, plant repotting, woodpile moving, and smoke house cleaning) (5). In France, a young woman who had harvested dusty grapes infested with red spider ascarids developed acute eosinophilic pneumonia after 7 days' exposure (6).

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We describe a New York City fireman who worked 16-hour days for 2 weeks, and who was exposed heavily to World Trade Center (WTC) dust after the September 11, 2001 terrorist attack. He developed acute eosinophilic pneumonia with hypoxia and a computed tomography (CT) scan showing patchy ground glass density, thickened bronchial walls, and bilateral pleural effusions. Bronchoalveolar lavage (BAL) revealed 70% eosinophilia with activated $CD4^+$ T cells and increased interleukin (IL)-5 content. Mineralogic analysis of the lavage fluid identified fly ash, degraded glass, and chrysotile and amosite asbestos fibers.

METHODS

Clinical Studies

Pulmonary function tests included spirometry and diffusing capacity for carbon monoxide. Predicted values for spirometry were those of Knudson and colleagues (7), and diffusing capacity was that of Van Ganse and coworkers (8). Noncontrast CT scans were performed (GE HiSpeed CT/1 helical scanner; GE Medical Systems, Milwaukee, WI) on the day after admission and 9 days later. On initial exam, 1-mm-thick sections were obtained at 10-mm intervals from the thoracic inlet through the upper abdomen at inspiration.

Bronchoalveolar Lavage Studies

Fiberoptic bronchoscopy with BAL was performed as described (9). The BAL cell pellet was fixed with 2% glutaraldehyde in 0.1 M sodium cacodylate buffer, embedded in Eponate-12 resin, and analyzed using a Zeiss EM-10 electron microscope (Zeiss, Thornwood, NY). BAL cell 24-hour supernatants for IL-1β, -4, -5, -6, -10, tumor necrosis factor (TNF)-α, and interferon (IFN)-γ were measured by ELISA (Pierce Endogen, Rockford, IL). Immunofluorescent labeling and flow cytometry were performed as previously described (9) and analyzed by four-color flow cytometry on a Becton Dickinson (Franklin Lakes, NJ) FACSCalibur. For particle analysis, the BAL cell pellet was suspended in sodium hypochlorite solution, agitated for 30 minutes, and the residue was collected on a 0.4-μm, 13-mm diameter Nuclepore filter for scanning electron microscopy at ×1,300–6,500 (10).

RESULTS

A 38-year-old firefighter was admitted to the Bellevue Hospital Medical Intensive Care Unit on September 24, 2001, due to hypoxic respiratory failure. He had arrived on the scene 20 minutes after the collapse of the WTC. He worked 16 hours/day for 13 days, inhaling smoke and dust since the collapse. He did not use respiratory protection the first 7 to 10 days and only occasionally after that. He developed cough for 2 to 3 days after the collapse, which produced blackish sputum. For 2 days before admission he had fatigue, myalgias, fever, dry cough, anterior pleuritic chest discomfort, and progressive dyspnea on minimal

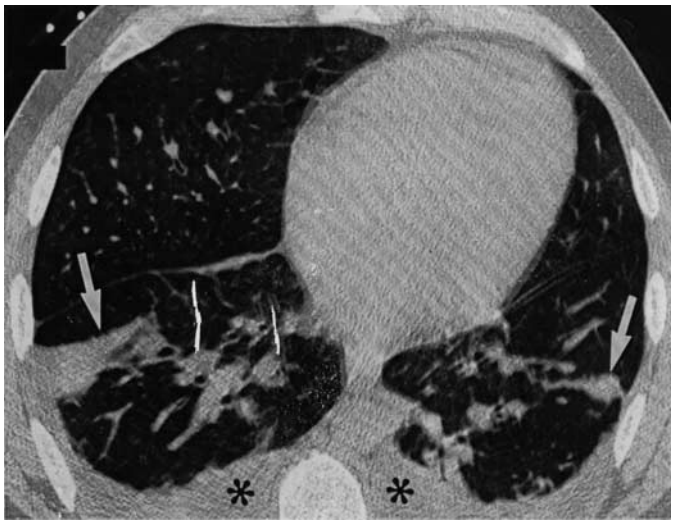
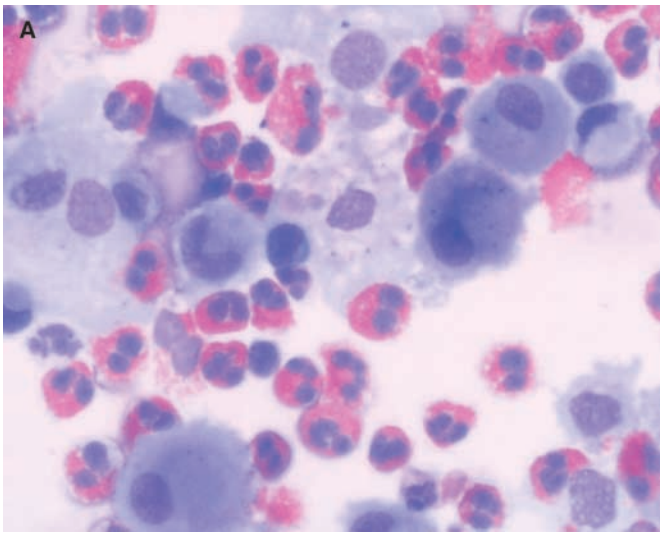


Figure 1. Chest CT. One-millimeter-thick section at the lung bases depicts patchy areas of consolidation (*arrows*). There is bronchial wall thickening and small pleural effusions (*asterisks*).



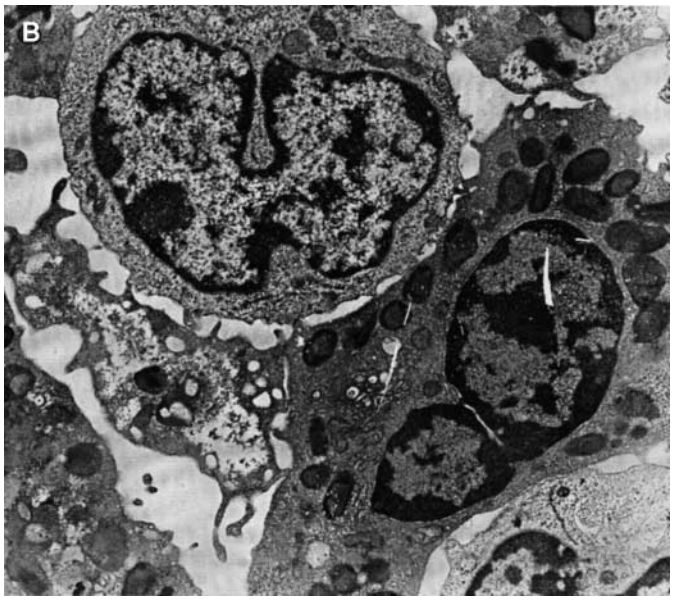


Figure 2. Cytospin of BAL cells. (*A*) Numerous eosinophils seen with alveolar macrophages containing few particles (original magnification: ×60). (*B*) Transmission electron micrograph of an eosinophil with intact lysosomes containing major basic protein (original magnification: ×6,300).

exertion (less than one block). He had been a New York City firefighter for 15 years. He had smoked 1 pack/day for 5 years, and quit 20 years ago. His only medication was rofecoxib for postsurgical knee pain, which he had taken regularly (25 mg, twice/day) from January to June 2001, daily in July, and about once/week in August and September 2001.

On admission, his heart rate was 120, respiratory rate 35, temperature 38.6°C, and blood pressure was normal. He had bibasilar rales. Laboratory tests were normal except for a WBC of 22,600 cells/mm^3 (91% neutrophils, 3% lymphocytes, 5% macrophages, and 1% eosinophils). His arterial blood gas was pH 7.46, Pa_{O_2} 53 mm Hg, Pa_{CO_2} 32 mm Hg, HCO_3 23 mEq/L, and O_2 saturation 89%. He was treated with oxygen, levoquin, and methyl prednisolone (125 mg intravenously and then 60 mg every 6 hours) for smoke inhalation injury. Blood and urine cultures did not grow any pathogens. Chest radiograph and CT scan (Figure 1) showed patchy ground glass opacifications, thickening of respiratory airways, and bilateral pleural effusions. Bronchoalveolar lavage recovered 730,000 cells/ml (normal < 250,000 cells/ml) with a differential of 70% eosinophils, 18% macrophages, 8% lymphocytes, and 4% neutrophils. His total IgE was 58 ng/ml (normal < 180 ng/ml), and BAL fluid IgE was 0.4 ng/ml. Pulmonary function tests performed after discharge from the medical intensive care unit on September 27, 2001, showed: FVC 3.8 L (86%), FEV_1 2.6 L (71%), expiratory flow at 50% FVC 1.90 L/second (40%), and $D_{L_{CO}}$ 23.1 ml/mm Hg/min (77%). His oxygen saturation at rest (94%) dropped to 87% after a brisk walk of 150 ft.

After treatment with corticosteroids for 9 days, pulmonary function tests improved. His repeat CT scan showed near complete resolution, and repeat BAL cell differential showed 39% eosinophils, 60% macrophages, and 1% lymphocytes. He was discharged and continued on oral prednisone for 3 weeks.

Figure 2A shows a cytocentrifuge preparation of cells from his first BAL fluid demonstrating striking eosinophilia. Transmission electron microscopy of a BAL eosinophil (Figure 2B) revealed intact lysosomes in the cytoplasm with central rectangular major basic protein granules present. No evidence of degranulation of lysosomal contents was seen in other fields.

B cells, NK cells, $CD8^+$ cells, and $CD4^+$ T cells in BAL were within the normal range. Alveolar $CD4^+$ lymphocytes displayed a highly stimulated surface phenotype. Half of these (42%, normal 81%) had lost expression of the early activation marker CD69 and expressed increased levels (88%, normal 39%) of the intermediate marker CD25, or low-affinity IL-2 receptor. Higher percentage of $CD4^+$ $CD25^+$ cells in the peripheral blood (70%, normal 57%) could have come from those activated in the lung. IL-5, an eosinophil chemotatic factor, was detectable in serum (24 pg/ml), BAL cell 24-hour supernatant (107 pg/10 cells/ml), and BAL fluid (16 pg/ml) on admission. No other cytokines were detectable above background.

There were 305 fibers per million alveolar macrophages. The types of fibers included chrysotile and amosite (Figures 3A and 3B). One chrysotile fiber measured 70 μm in length and 0.2 μm in diameter. Nonasbestos fibers included chromium and predominately silicon-containing fiber that probably represented de-

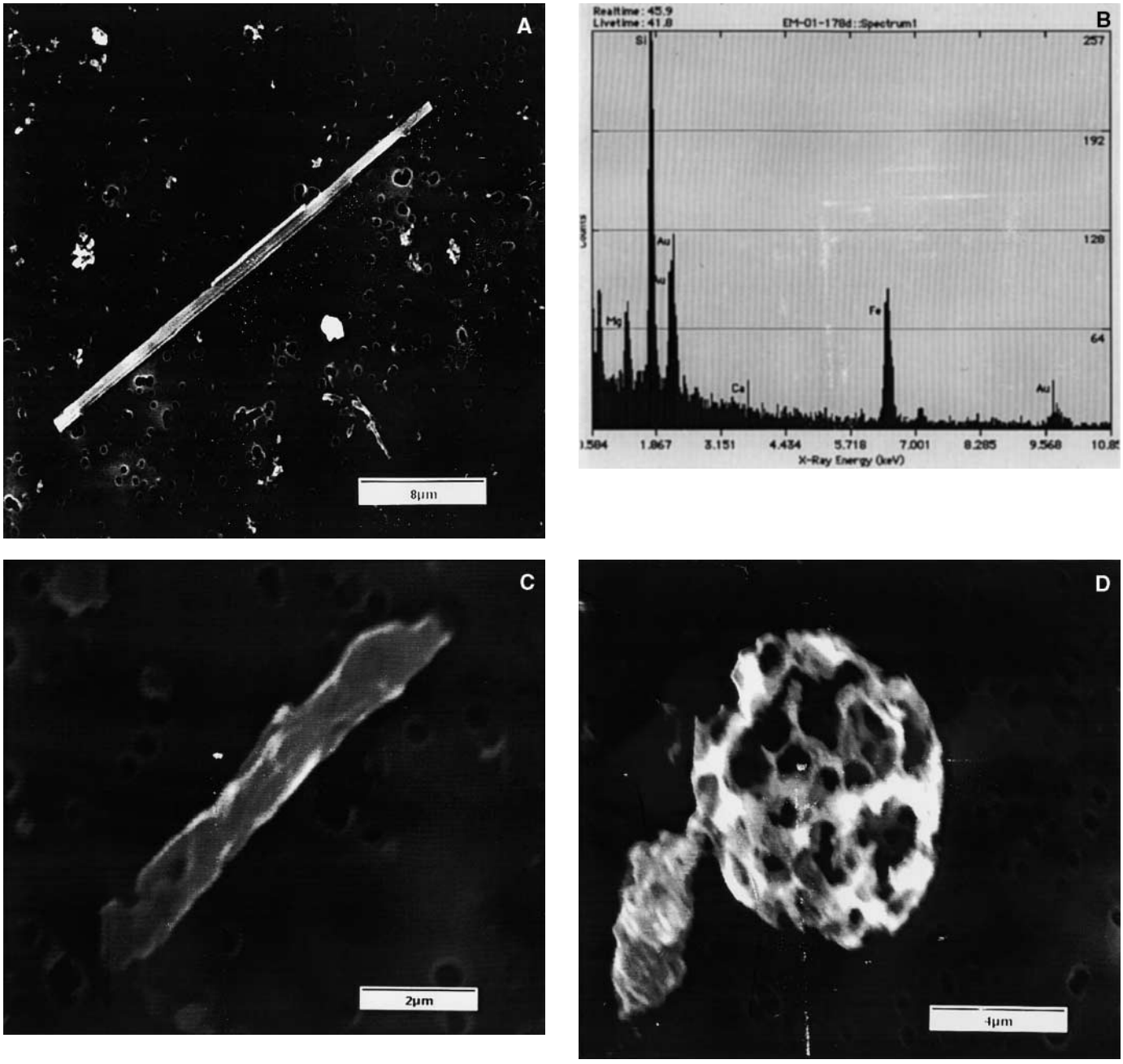


Figure 3. Mineralogic analysis of particles. (*A*) Amosite asbestos fiber (uncoated) 33 µm in length by 1 µm in width. (*B*) Elemental analysis shows presence of magnesium (Mg), silicon (Si), and iron (Fe) consistent with the pattern for amosite. (*C*) Degraded fibrous glass. (*D*) Fly ash particle.

graded fibrous glass (Figure 3C). A variety of nonfibrous particles were identified, including fly ash (Figure 3D), silica, metal particles, and various silicates (from 61 consecutive particles).

DISCUSSION

The September 11, 2001, terrorist attack on the WTC and its subsequent fire and collapse released tons of dust on lower Manhattan. Practically all 11,500 New York City firefighters participated in rescue and recovery operations over the first 2 weeks. Approximately 5,000 tons of asbestos was used for fireproofing in construction of the WTC towers up to approximately the 40th floor (11). Air samples in the weeks since the attack have shown that the 8-hour time-weighted average levels of airborne asbestos fibers have been generally below federal standards. Size fractionation of airborne samples revealed that approximately 0.4 to 2% of the dust was respirable (< 10 µm) and most of this was in the fine fraction (< 2.5 µm) (Dr. Lung Chi Chen, personal communication). Our sentinel case of acute eosinophilic pneumonia met the six criteria of Pope-Harman and colleagues: acute onset, fever, bilateral infiltrates on chest imaging, severe hypoxemia, lung eosinophilia, and no history of drug hypersensitivity or infection (5). It is interesting that many of the cases of acute eosinophilic pneumonia reported in the literature had acute, high dust exposures (4–6). The environmental dust exposures were predominantly due to large environmental particles such as WTC dust.

IL-5 promotes the terminal differentiation of committed eosinophil precursors, prolongs the survival of eosinophils, and is a characteristic cytokine of the Th2 phenotype (12–15). Interestingly, the eosinophils had not degranulated, in contrast to acute tropical eosinophilia, in which the alveolar eosinophils lose their granule and lysosomal contents (16). In acute and chronic tropical eosinophilia, the eosinophilic infiltration is characterized by tissue injury and interstitial fibrosis (17). The absence of other inflammatory cytokines in the BAL fluid or supernatants suggests a more benign course in acute eosinophilic pneumonia without tissue destruction. Coexpression of CD25 and CD69 on $CD4^+$ T cells in our patient was 35% (normal volunteers 8%), consistent with activated alveolar lymphocytes secreting IL-5 to recruit eosinophils to the lower respiratory tract.

Mineralogic analysis identified fly ash, degraded glass, and 305 chrysotile or amosite asbestos fibers per million macrophages using scanning electron microscopy and energy-dispersive X-ray analysis (10). Long narrow fibers less than 0.5 μm in diameter by more than 8 μm in length have the greatest association with mesothelioma induction in a rat pleural implantation model (18). Roggli and colleagues have reported that findings of more than 1 asbestos body per 10^6 macrophages had a sensitivity and specificity of 89% for asbestosis (10). Commercial asbestos fibers (chrysotile or amosite) are rarely found in alveolar macrophages lavaged from normal volunteers or patients with interstitial lung disease (10, 19–20). The number of uncoated asbestos fibers found in the macrophages from our acutely and heavily exposed firefighter is consistent with recent exposure, because no coated asbestos bodies were identified.

We report a case of acute eosinophilic pneumonia in a New York City firefighter exposed acutely to high levels of WTC dust. Mineralogic analysis demonstrated asbestos fibers with high aspect ratios recovered by BAL from the lower respiratory tract. Such findings emphasize the need for workers at WTC to wear particulate respirators, and to comply with on-site health and safety regulations. Firefighters and rescue workers from the region and around the country were exposed to WTC dust and may be at risk for WTC cough and asbestos exposure.

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