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Chronic Reactive Airway Disease following Acute Chlorine Gas Exposure in an Asymptomatic Atopic Patient*

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While chlorine gas inhalation has previously been reported to cause temporary mucous membrane irritation, acute pneumonitis, pulmonary edema, and transient bronchospasm, there is controversy about the existence of long-term pulmonary sequelae. We report the case of a 25-year-old man in whom chronic, recurrent asthma developed after exposure to a chlorine gas leak in an enclosed space. His course since the exposure has been notable for frequent exacerbations necessitating chronic corticosteroid therapy and multiple hospitalizations. To our knowledge, the persistence of symptoms years after the exposure is unique in the literature. ***(Chest 1991; 100:855-56)***

Chlorine is widely used in water purification and in the manufacture of plastics, bleaches, and alkalis. Although its pungent odor is detected in concentrations as low as 0.5 ppm, it causes respiratory damage only at levels above 20 ppm. Discovery of the highly toxic effects of chlorine gas on the human respiratory tract resulted in its deployment as the first chemical weapon at Ypres, France, in 1915. Despite extensive study since that time, controversy still exists about long-term pulmonary sequelae after acute chlorine-induced lung injury. We report a unique case of severe, chronic asthma following acute exposure to chlorine gas.

Case Report

A 25-year-old man came to the Hahnemann University Hospital Emergency Room with severe dyspnea. He had a history of mild childhood asthma, which had resolved at the age of 5 years. Four years prior to admission, the patient was exposed to a chlorine gas leak while working for a regional sewerage authority. The patient had worked for 2 h in a chlorine-filled enclosed environment without a protective respirator mask. Immediately following this exposure, the patient experienced a transient episode of hemoptysis followed by acute shortness of breath and wheezing. A regimen of aminophylline and inhaled beta-agonists was started in a local emergency room, which resulted in some improvement in his symptoms. His course over the next 4 years was notable for frequent hospitalizations for asthma and increasing use of oral and inhaled corticosteroids. He was admitted to Hahnemann University Hospital for management of an acute exacerbation of his illness and a diagnostic workup.

Physical examination revealed an afebrile, cushingoid patient in moderate respiratory distress. Auscultation of the chest revealed diffuse expiratory wheezes in all lung fields with prolonged expiration.

An arterial blood gas evaluation on room air revealed a pH of 7.45, a P_{CO_2} of 32.2, and a P_{O_2} of 73.6. The eosinophil count was 8 cu mm; the immunoglobulin G activity was markedly elevated at 431 U/ml (normal, <122 U/ml). A chest roentgenogram was normal except for minimal peribronchial thickening. An esophagram demonstrated minimal gastroesophageal reflux without aspiration. An *Aspergillus* skin test was negative. A flow volume loop and otorhinolaryngologic evaluation showed no evidence of upper airway obstruction. Pulmonary function testing revealed an FVC of 2.71 (52 percent of the predicted value [PV]), an FEV_1 of 1.42 (35 percent of PV), an FEV_1/FVC of 52 percent, an FRC of 5.09 (154 percent of PV), and a TLC of 7.43 (107 percent of PV)—values consistent with severe obstruction (normal values from Crapo et al[1]). Administration of aerosolized albuterol produced a 54 percent improvement in FEV_1 and a 26 percent improvement in FVC, which was reproduced in multiple studies. The single breath diffusion capacity for carbon monoxide was 31.95 (89 percent).

Intravenous methylprednisolone, intravenous aminophylline, and aerosolized terbutaline were given with significant improvement in the patient's symptoms and flow rates, although moderate obstruction remained. After several days, the patient was discharged on a regimen of high-dose oral corticosteroids with persistent airflow obstruction.

Discussion

Although today most reported cases of chlorine exposure occur in industrial settings,[2,3] at water treatment facilities,[4] or as a result of transportation accidents,[5,6] several cases of toxic chlorine inhalation have occurred in more unusual circumstances. An increasingly common source of exposure to chlorine gas is fumes liberated from chlorine products used in residential pools and spas.[7,8] Cases of exposure resulting from chlorine gas released during mixing of a variety of household cleaning agents[9] have prompted the placement of consumer warnings on many such products. One episode of voluntary exposure has also been reported.[10]

The long-term pulmonary sequelae of chlorine gas inhalation are controversial. Studies of soldiers gassed during the First World War showed evidence of obstructive airway disease and permanent disability.[6,11] It is difficult to ascribe abnormalities found in these patients solely to chlorine inhalation for two reasons: chlorine was used only for a short time in chemical warfare, and most subjects studied were exposed to multiple war gases.[12] More recent series describe an initial obstructive defect, often with partial reversibility[2,13,14]; restrictive defects with accompanying diffusion abnormalities have also been reported.[7,14] These initial changes reverted to normal within a few months in almost all patients studied. In fact, in a study involving 820 patients, Jones[15] found no radiologic or clinical evidence of permanent pulmonary damage following industrial chloride exposure. Lawson[16] also found no long-term residual changes in laboratory parameters, chest roentgenographic findings, or pulmonary function test results in over 457 cases of acute industrial chlorine gas exposure. In contrast, Kaufman and Burkons[12] found persistent obstructive lung disease up to 14 months following chronic chlorine exposure, and Kowitz et al[5] found persistent residual restrictive disease and low diffusing capacities up to 3 years following acute chlorine exposure. In another study, Jones et al[8] found that long-term sequelae after acute chlorine gas exposure were affected more by cigarette smoking than by the

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chlorine gas exposure. Other authors[17] have suggested that preexisting lung conditions do not affect the occurrence of pulmonary sequelae following chlorine gas exposure.

Our patient was exposed to chlorine gas in an industrial setting. Although the patient had a history of cigarette smoking and childhood asthma, he had had no symptoms of reactive airways disease for 20 years prior to this event. Following the chlorine exposure, the patient's symptoms rapidly became severely debilitating, necessitating daily therapy with high-dose corticosteroids, frequent use of home oxygen, and self-administered subcutaneous epinephrine.

To our knowledge, this case is unique in the literature. Charan et al[3] showed reversible acute airway obstruction shortly after exposure, and Hasan et al[13] reported the cases of two asthmatic patients in whom chlorine gas may have exacerbated a state of underlying hyperactivity. No one, however, has reported new onset of severe reversible airway obstruction that persisted several years after chlorine gas exposure. Thus, we believe that our patient represents a unique case of persistently debilitating asthma following acute chlorine gas exposure.

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Successful Management of CMV Pneumonia in a Mechanically Ventilated Patient*

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We report a case of severe respiratory failure due to cytomegalovirus pneumonitis in a patient who underwent an allogeneic bone marrow transplant, who was successfully treated with the combination of ganciclovir and high-dose intravenous immune globulin. We also reviewed the rationale for the use of combination therapy with an antiviral agent and immunotherapy. Because of the bone marrow toxicity of ganciclovir, an aggressive diagnostic approach, including bronchoalveolar lavage and open lung biopsy, may be necessary to establish a definitive diagnosis prior to institution of therapy. ***(Chest 1991; 100:856-58)***

CMV = cytomegalovirus; ABMT = allogeneic bone marrow transplant; IVIG = intravenous immune globulin; PTD = posttransplant day; GVH = graft-versus-host

Respiratory failure secondary to cytomegalovirus pneumonitis is a serious complication in allogeneic bone marrow transplant patients. Even though encouraging results have been reported in patients treated with a combination of ganciclovir and intravenous immune globulin,[1,2] none of them was intubated or mechanically ventilated. We report a case of severe respiratory failure secondary to documented CMV pneumonitis requiring mechanical intubation and mechanical ventilation in an ABMT patient who was successfully treated with a combination of ganciclovir and high dose IVIG.

Case Report

A 33-year-old white woman was diagnosed with acute myeloblastic leukemia in December 1988. She underwent induction chemotherapy with daunorubicin, cytosine arabinoside, and thioguanine at that time and consolidation chemotherapy with the same agents in January 1989. She subsequently received a non-T-cell depleted ABMT on April 12, 1989. The posttransplant course was complicated by pulmonary hemorrhage and respiratory failure on posttransplant day 14, requiring ICU admission, intubation, and mechanical ventilation. The patient was treated with broad spectrum antibiotics and amphotericin B for persistent fevers, despite negative bacterial cultures and was extubated on PTD 20. On PTD 43, she developed a nonproductive cough; pulmonary function tests revealed a D_{CO} of 41 percent and a PaO_2 of 55 mm Hg while breathing room air. Intravenous pentamidine was added at this time for possible *Pneumocystis carinii* pneumonia. Bronchoscopy with biopsy of the right middle lobe and bronchoalveolar lavage were negative for bacterial cultures, PCP stains, Legionella DFA, AFB smear, CMV monoclonal antibiotics, and mycology stains. A gallium scan demonstrated mild increased uptake in the right lower lobe. Over the next several days, there was a progression of the RLL infiltrate associated with persistent nonproductive cough and fever. On PTD 49, the patient underwent a right thoracotomy for open lung biopsy; histologic findings and monoclonal AB were positive

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