SULFUR DIOXIDE CHEMICAL PNEUMONIA; REPORT OF A CASE WITH RECOVERY FOLLOWING ACCIDENTAL EXPLOSION OF A REFRIGERATOR UNIT*

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IT is apparent that with increasing industrialization man is surrounding himself with ever increasing health hazards. Of these, one of the most important is the inhalation of irritating gas. Physicians became aware of its effect on the bronchopulmonary system during the first World War when poison gas was em-

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ployed as a weapon. Exposure has since become increasingly common in association with numerous chemical developments in industry. One of these is the use of sulfur dioxide in modern refrigeration. The toxic effects of this gas have been noted in recent reports dealing with occupational disability in the refrigerating and sulfur mining industries. These investigations were concerned mainly with the results of long continued inhalation of small amounts of the gas.[1] Chronic bronchitis and increased susceptibility to colds have been common sequelae of such exposure. Needles and Smith[2] reported on the late effects of acute sulfur dioxide poisoning in a patient who came under their observation with widespread tubular bronchiectasis and sharply reduced respiratory function. Martini, Dossola and Celener[3] have recorded the first death caused by chemical pneumonia due to sulfur dioxide poisoning. We wish to report a similar case with recovery, exemplifying (1) the rapidly destructive effect of concentrated sulfur dioxide inhalation, and (2) the apparently beneficial result of sulfonamide therapy.

Case Report

B. B., aged 15, was admitted to the Jewish Hospital November 11, 1940. The history revealed that he had found a refrigerator unit on a vacant lot and that while dismantling it, the tank blew up in his face. Further investigation showed that the fumes consisted of sulfur dioxide.

Upon admission to the accident ward about 15 minutes after the accident, the boy was very weak, dyspneic, hoarse, and unusually cyanotic. The temperature was 102.4° F., the pulse rate 140, the respiratory rate 42 per minute. There was considerable edema of the eyelids with chemosis. Widespread erosions of the conjunctivae, the nose and mouth attested to the severity of the chemical burns. The larynx was inflamed, its mucosa eroded, but there was no obstruction of the glottis. The rapid respiratory rate, the limitation of expansion in the left lower lobe, the impaired percussion note over both bases and the presence of many inspiratory râles, particularly over the left lower lobe, all indicated a rapidly progressive bronchitis and bronchiolitis. The heart was not displaced. Its action was regular but very rapid, and the sounds were of reduced volume. No murmurs were heard. The abdominal examination was negative.

Early signs of consolidation were apparent within 12 hours and frank consolidation was present in 24 hours.

Forty-eight hours after admission a roentgenogram showed a localized area of haziness obscuring the left costophrenic sulcus and extending up to the ninth rib. The roentgenologic appearance was that of a basal bronchopneumonia associated possibly with a diaphragmatic pleurisy.

The patient was placed in an oxygen tent because of his dyspnea and cyanosis. Dehydration was combated by daily venoclysis of 2000 c.c. of 5 per cent glucose in normal saline solution. The patient also received a transfusion of 250 c.c. citrated blood. He was given sulfathiazole, receiving 11 grams in 36 hours, at which time the blood concentration of the drug was 3.3 mg. per cent. The temperature began to decline from its high level of 104° and was normal on the fifth day of therapy, after 25 grams of sulfathiazole had been given. At this time the signs of pulmonary consolidation disappeared, but residual bronchitis was evident.

Roentgen-ray examination on November 25 revealed that the pneumonia had undergone complete resolution, but some intensification of the bronchial markings at the right base was evident.

Laboratory examination on November 12 showed 67 per cent hemoglobin, 3,700,000 erythrocytes, 17,600 leukocytes, of which 93 per cent were polymorphonuclears.

In the absence of productive cough, no sputum examination was made. Throat cultures revealed streptococci, staphylococci and pneumococci. The latter were type 22, a "high number type" of doubtful significance. A blood culture remained negative. There was no evidence of renal disturbance. The indirect van den Bergh was slightly elevated to 0.75 mg. per cent. (At no time was clinical jaundice noted.) We were unable to make any tests for sulfhemoglobin in the blood.

The boy was discharged on November 26, although it was thought that the cyanosis had not entirely disappeared.

Following his discharge he remained intermittently under our observation (H. G.). He suffered frequent attacks of lacrimation and sneezing. Hoarseness and cough persisted. The latter, worse in the night, was associated with morning expectoration of thick, greenish, purulent sputum. Night sweats persisted for two weeks after leaving the hospital, but there was apparently no fever except for a period of one week during the Christmas holiday. The boy complained of nervousness and extreme fatigue which prevented his return to school until early in January 1941. The school authorities thought that he had become mentally retarded.

On February 1, 1941, a roentgenogram revealed definite intensification of the lung markings in both lower lobes, especially the right. At his last follow-up examination in April 1941, the boy complained of lacrimation, although no gross conjunctival change was noted. A posterior ethmoiditis and hyperplastic pharyngitis were present. The cough and morning expectoration continued apparently unassociated with fever or weight loss. Transient râles were heard at both lung bases. In view of the continued morning expectoration of purulent sputum and the roentgenographic appearance of the lungs, bronchiectasis was considered to be present in both lower lobes. Bronchography was advised but was not done.

Discussion

Sulfur dioxide, widely used in refrigeration, is considered ideal for that purpose in that it is non-explosive and non-inflammable.[4] It is, however, one of the most irritant gases, so much so that Alice Hamilton considered it irrespirable and thus massive exposure impossible insofar as the respiratory tract is concerned.[5] This is not altogether true as evidenced by the experience of others [2, 3] as well as ourselves. In fairly high concentration the gas is corrosive, forming sulfuric acid on combining with water. Its destructive action on the moist surfaces of mucous membranes is thus explained.

Sulfur dioxide is thus similar in its action to nitrogen dioxide and tetroxide which, combining with water, give rise to another corrosive acid, namely, nitric acid.[6] Although experimental work on sulfur dioxide poisoning has not been extensive as in the case of nitrogen tetroxide and the war gases, it is believed that the pathologic changes are fundamentally alike in most of these irritant gases, possibly in all of them.[7] The great damage caused by them in both experimental animals and man is in the bronchi and bronchioles, with erosion of the lining epithelium, deciliation, edema of the underlying submucosa, spasm of the bronchial muscle and thrombosis of the small arteries and veins.[6, 8] With inhalation of concentrated fumes, the acute process extends into the alveolar ducts and the alveoli. In the latter, the inflammatory exudate consists of fibrin and plugs of desquamated cells resembling a picture of the so-called lobular catarrhal pneumonia. However, uniform lobar involvement may occur both experimentally and clinically. Death may come quickly, i.e., on the first day, as a result of pulmonary edema, somewhat later because of pneumonia. Survival over many days allows bronchial and alveolar regeneration, often attended, however,

with striking epithelial metaplasia,[6, 9] bronchial necrosis, bronchiolitis obliterans, bronchiectasis.[2] The acute erosive changes and the subsequent alterations in the course of regeneration favor bacterial invasion of the lung parenchyma. Coplin in discussing the delayed deaths in war gas poisoning said that he never saw a case in which bacteria were not abundant in the lungs, noting especially the common incidence of streptococci and gas bacilli. The latter point is important inasmuch as bacterial invasion was once not considered essential to the development of chemical pneumonia.[11]

These observations on the pathological changes are pertinent to the clinical and therapeutic considerations of such cases as our own. Our patient is one of the few instances, apparently the second recorded case, and the first to recover, of acute chemical pneumonia caused by sulfur dioxide. The symptomatology of these two cases was practically identical in its abrupt and explosive development with that noted in numerous cases of nitrogen tetroxide poisoning, and it seems reasonable to discuss them as a group in the light of recent therapeutic advances. One is impressed with the high mortality figures in reports of nitrogen tetroxide poisoning. Schubert (1911) collected 213 cases, of which 55 were fatal (24 per cent).[12] In those cases in which pneumonia was definitely present, the mortality was much higher, being 100 per cent in many small series of cases.[13, 14] The majority of these victims died within four days of exposure, often within 48 hours. The marked cyanosis and dyspnea, the rapid course, and the picture of "medical shock" are reminiscent of what was seen in the 1917–1918 pandemic of influenza. In this connection, the resemblance of the pathologic findings was commented on by Winternitz.[8, 15] The important common factors were apparently the swift local destruction of respiratory surface barriers and the subsequent collapse of resistance to mixed bacterial invasion. Physicians today possess a therapeutic weapon theoretically adequate for such a situation, namely, the sulfonamide drugs, which by their bacteriostatic action on many types of organisms allow time for the patients' recuperation and the development of humoral defense.

The administration of sulfathiazole to a patient with sulfur dioxide poisoning presented a therapeutic problem. In view of the patient's cyanosis the presence of sulfhemoglobinemia was a possibility and is considered by some to be a contraindication to sulfonamide therapy. In retrospect, we believe that sulfathiazole was highly effective. It is to be noted that in the case of Martini and Dossola, an 18 year old boy previously in good health, modern therapy consisting of oxygen, intravenous administration of glucose and saline, and a fair degree of digitalization was of no avail. A comparison based on single cases or even on small groups is inconclusive, but the data herein presented suggest that sulfonamide therapy in chemical pneumonia may be beneficial and should be administered early in effective dosage. In the absence of spectroscopic examination, the presence of sulfhemoglobin in our case remained questionable. It was noted above that early and often striking cyanosis is common to nitrogen tetroxide, chlorine and bromine pneumonitis. Occasional spectroscopic examinations, clinical and experimental, have shown that methemoglobinemia is not the cause of the cyanosis.[14, 16] The latter is due apparently to acute exudative edema interstitially and in the alveoli causing acute anoxemia.

Chronic Sequelae. With a single exception,[17] clinical reports agree on the bad chronic effect, chiefly on the bronchi, resulting from sulfur dioxide inhala-

tion. These reports are based on long range observations in the industries in which an increasing incidence of "colds," bronchitis and dyspnea has been noted despite an increasing tolerance shown by many workingmen incidental to long continued exposure.[18] In occasional constitutionally susceptible individuals bronchial asthma appears to have followed such exposure.[19, 20] Acutè poisoning, if survived, should almost certainly lead to chronic bronchitis. Bronchiectasis was observed by Needles and Smith, and our patient is apparently following a similar course. Koontz,[20] basing his conclusion solely on experimental animal work, thought dogs that survived acute chemical inflammation of the respiratory tract usually made a complete recovery. It is doubtful whether such laboratory findings are entirely applicable to man. Clinical observation suggests otherwise. Bronchiectasis once established ordinarily presents a difficult therapeutic problem. It may well be that sulfonamide therapy, employed in our case with apparently striking benefit, might have been utilized in suitable dosage with equally important results in the later afebrile and subchronic stages. It is clear that bronchiectasis progresses mainly by reason of persistent infection, and prolonged small dosage of the sulfonamides may conceivably have another useful field in such cases as our own.

Summary

Concentrated sulfur dioxide inhalation may lead to acute inflammation of the respiratory tract, culminating in "chemical" pneumonia. After such exposure, a boy, aged 15, previously well, quickly showed signs of bronchopulmonary involvement. Cyanosis and dyspnea were notable features. Sulfathiazole therapy contributed to recovery, but its use limited to the acute phase of the illness did not prevent the later development of bronchiectasis.

The almost fatal accident leading to this illness was caused by the dismantling of a discarded refrigerator unit. The existence of such hazards should be publicized.

Since this article was submitted for publication, the following case has been observed.

G. T., aged 46, a junk dealer, was admitted to the Jefferson Hospital, Philadelphia, on October 6, 1941, to the surgical service of Dr. George P. Muller. The patient gave a history of hammering an old refrigerator unit which exploded with the sudden release of a gas which was considered to be sulfur dioxide. The patient was brought to the hospital within 15 minutes following the accident. At this time there were evidences of first degree burns of the face, eyes, nose and throat.

He complained of marked chest pains. He had a fever of 102° F. and a leukocyte count of 17,900 per cu. mm. A pneumonitis was suspected. Dr. Hobart Reimann found a few scattered râles in the right lower lobe. The roentgen-ray report on October 9, 1941 revealed "prominence of the hilar and parenchymal markings bilaterally, a little worse on the left side as is seen in tracheo-bronchitis."

Since his discharge on October 14, 1941 he has complained of postnasal dripping, cough and substernal pains, and the expectoration of thick mucopurulent sputum. He has become "nervous," that is, he frequently has felt "light-headed" and confused when driving his car. None of these symptoms existed prior to his accident.

He is being observed for any progressive changes in his lungs, especially early bronchiectasis.

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