ABSTRACT

Selected aspects of the pneumoconioses are briefly reviewed. Coal-worker's pneumoconiosis is a complex disease involving multiple pathogenetic factors which can modify the outcome considerably. The development of diffuse pulmonary fibrosis in some patients may be determined by immunologic mechanisms. The risk of neoplasia from occupational exposure to asbestos is great, and the tumors develop irrespective of the extent of pulmonary fibrosis. Chrysotile fibers can be identified frequently in the lungs of urban dwellers without occupational exposure. Chronic berylliosis is truly a systemic disease, and its manifestations include hyperglobulinemia, decreased tuberculin reactivity, hyperuricemia and hypercalciuria. The extrinsic allergic pneumonias, secondary to the inhalation of various dusts of vegetable origin, are thought to develop from the deposition of immune complexes within pulmonary blood vessels.

Coal-Worker's Pneumoconiosis (CWP)

The pathogenesis of coal-worker's pneumoconiosis is complex and not fully understood. It appears that the coal in the dust can serve as the primary etiologic agent, but other factors which often play important modifying roles include (1) the silica content of the dust, (2) air pollution by agents such as hydrocarbons and nitrogen oxides, (3) cigarette smoking, (4) coexistent tuberculosis and (5) constitutional factors, such as an associated impairment in the mechanism whereby the respiratory tract clears itself of foreign particles. This mechanism has two components—(1) mucociliary "escalator" action of tracheobronchial epithelial cells and (2) alveolar clearance. The former may be significantly impaired by disorders such as chronic bronchitis and fibrocystic disease of the pancreas; the latter by alveolar proteinosis and idiopathic pulmonary microlithiasis. In 1969, Buechner and Ansari described a new variant of acute silicosis in sandblasters which they termed silicoproteinosis. There were four patients who developed, within an average of 4 years after exposure, a rapidly fatal disease characteristic of acute silicosis clinically but with histopathologic changes of alveolar proteinosis.

The characteristic lesion in the simple (uncomplicated) type of coalworker's pneumoconiosis is a multifocal, avascular nodular fibrosis. The reacting cells most probably originate from the alveolar membrane and not from the blood. Coal dust itself
stimulates the production of some reticulin fibers, but the amount of collagen produced depends largely on the silica content. Progressive massive pulmonary fibrosis develops in a minority of cases and acid-fast bacilli have been demonstrated in about 40 percent of such patients. Experimentally, simple CWP can be converted into the massive progressive type by the synergistic effects of virulent or avirulent tubercle bacilli or nonfibrogenic dusts. It is likely, but not yet proved, that the "conversion factors" are immunologic.

It is well known that patients with rheumatoid arthritis and co-existent lung disease are prone to develop multiple peripheral pulmonary nodules which resemble histologically the subcutaneous rheumatoid nodules, as well as a diffuse type of pulmonary fibrosis.14 The association with pneumoconiosis, described as Caplan's syndrome, has been noted in coal workers, foundry workers and boiler scalers, as well as in a few cases of asbestosis. More recently, the analogue of Caplan's syndrome has been reported in a sandblaster with scleroderma.22

Asbestosis

The risk of malignant neoplasm from occupational exposure to asbestos is considerable. Among asbestos insulation workers in New York City,15 about one in five deaths is due to lung cancer and one in 10 to mesotheliomas, gastrointestinal neoplasms or cor pulmonale. There is a predominance of lower-lobe origin in asbestos-associated lung cancers. Some, but not others,4 have also found a higher incidence of peripheral tumors and of adenocarcinomas. These neoplasms occur with increased frequency even in workers with little or no radiologic evidence of pulmonary fibrosis; and the few reported data indicate that the asbestos content of the lungs is quite small (0.6 percent or less).16 Whether or not there exists a threshold dose and the nature of the dose-tumor response curve are crucial questions which remain unanswered.

An even more important problem is the extent of non-occupational exposure through environmental pollution or other sources. That this can be significant was suggested by epidemiologic studies reported from South Africa in 196020 and from London in 1965,9 in which a significant number of cases of mesothelioma were found to occur in persons with only "family" or "neighborhood" exposure. The subsequent frequent demonstration of asbestos bodies in the lungs of urban dwellers did not settle the question since it was not proved that their cores were invariably asbestos. The search, with the light microscope, for asbestos fibers and fibrils in digested sections of lungs has yielded positive results in nearly 50 percent of the cases. The technique, however, is hampered by a high incidence of background contamination and by the fact that the fibrils less than 1 μ in diameter, which are more characteristic of chrysotile asbestos (the type most prevalent in the USA), are less numerous and more difficult to identify. Specific identification requires techniques such as electron microscopy and electron microprobe analysis. Two studies which utilized the former method have been reported recently by Selikoff and associates16 from New York and by Pooley and others12 from London. In both, a high incidence of asbestos fibers was found in the lungs of urban dwellers. The former group of investigators also has found chrysotile asbestos in about 33 percent of samples of 17 widely used drugs, including antibiotic agents.11 Precisely what all this means in terms of disease for persons who are exposed non-occupationally perhaps will be determined by future quantitative studies.

Berylliosis

The use of beryllium in the United States has increased 500-fold during the past 20 years. Chronic berylliosis, which also can
occur from non-occupational neighborhood exposure, develops in only a small percent of those exposed, but the factors which determine individual susceptibility are unknown. It is truly a systemic disease inasmuch as high concentrations of beryllium have been found in almost every organ, except perhaps the brain, whether or not the tissue shows histopathologic changes. The metal can also be detected in tissue sections by laser microprobe and emission spectroscopy. Pulmonary fibrosis characteristically is most marked in the upper lobes, although the average beryllium content is not greater in the upper lobes than in the others.

Four additional findings which deserve mention because they are relatively frequent include (1) decreased tuberculin reactivity (without increase in the incidence of tuberculosis), (2) hyperglobulinemia in about 40 percent, (3) hyperuricemia, apparently due to decreased renal clearance rather than increased production, and (4) hypercalciuria (20 percent) associated in fewer instances with hypercalcemia or renal stones, or both.

Other Mineral Dusts

Many other types of pneumoconiosis secondary to mineral dusts have been recognized but there is no space here to review them adequately. Silica or silicates are the principal cause of the pulmonary fibrosis after occupational exposure to graphite, fuller earth, talc and Kaolin (china clay), as well as in arc-welder’s lung.

The pulmonary lesions from hematite are due to silica modified by the presence of iron. It resembles the pneumoconiosis of coal workers and involves the upper lobes most severely. The serum concentration of inorganic iron is elevated in some patients. The complications include bronchiectasis, tuberculosis, and pulmonary carcinoma.

Bauxite lung, also known as Shaver’s disease, develops in persons who work with aluminum abrasives. The fumes contain about 7 percent silica, but typical silicotic nodules have not been found in the reported cases and the etiology of the pulmonary changes remains obscure.

Most cases of pulmonary disease following exposure to aluminum have appeared in the European medical literature. The particles of aluminum metal powder usually are larger than 5 μ, but smaller ones apparently are present in sufficient concentration to become a hazard in selected instances. The pulmonary lesion is an interstitial fibrosis similar to that seen in bauxite lung, the most severe changes being located near the pulmonary hila.

Silica does not play a role in the pathogenesis of the massive pulmonary fibrosis which may develop in some carbon-electrode makers. The lesions are thought to result from the additive effects of carbon dust and low-grade tuberculosis infection.

The inhalation of dust from fiberglass plastic reportedly has produced pulmonary reactions in human beings, and the irritant is calcium carbonate.

Silver-polisher's lung was first described in 1945. The dust inhaled contains iron oxide and metallic silver. The latter combines with tissue proteins and stains the tissues black.

Stannosis results from prolonged inhalation of dust or fumes of tin oxide. The particles are deposited in the alveolar septa, subpleurally and around bronchioles and blood vessels, but do not elicit much fibrosis.

Acute exposures to fumes containing cadmium can produce fatal pulmonary edema and chemical pneumonia. The changes in cases of chronic exposure consist of moderately severe perivascular fibrosis and infiltration with lymphocytes. Proteinuria is a common finding and the urine contains complexes of cadmium and protein.
Extrinsic Allergic Pneumonias

The concept of "extrinsic allergic pneumonias" encompasses most of the pulmonary reactions reported to occur after the inhalation of vegetable dusts. The basic mechanism is held to be the deposition within pulmonary blood vessels of immune complexes consisting of antigen in excess, IgG or IgM antibody, and often also complement. These deposits elicit acute inflammation with or without necrosis, in a manner analogous to the pathogenesis of post-streptococcal nephritis and lupus nephritis.

The prototype is farmer's lung, which first develops 6 to 10 weeks after exposure to moldy hay containing the antigen, a polysaccharide of actinomycetes. The histopathologic changes in the lungs vary with the stage of the disease. In the early phases, there is interstitial infiltration with mononuclear cells, predominantly lymphocytes, but well-defined granulomas are noted in a minority of cases (9 of 24 cases in one reported series). Later, the changes resemble sarcoidosis or berylliosis. The presence of doubly refractile bodies, probably particles of the inhaled material, has been noted in about half of the cases. Although vasculitis is a common finding, the predominant lesion is a non-necrotizing granulomatous pneumonia. This fact suggests that another mechanism, involving delayed-type of hypersensitivity, may also be operative, although antigen-antibody complexes reportedly can produce granulomas. About 10 percent of the patients die within six years of diagnosis. After withdrawal from exposure, 70 percent of survivors become asymptomatic and the others remain dyspneic.

Characteristically, the dyspnea of patients with bagassosis is severe and out of proportion to the physical findings. In the great majority of cases, recovery is complete, but a few have developed chronic pulmonary disease with reduction in the maximal breathing capacity. The functional abnormalities resemble those found in farmer's lung. Relapses are frequent and are prone to occur at variable periods of time after re-exposure. Structural changes in the lungs have been noted only after prolonged exposure and have consisted chiefly of an interstitial pneumonia with the inflammatory cells predominantly mononuclear. Although the sera of affected persons frequently contain precipitins against extracts of bagasse, these are found almost as frequently in normal unexposed persons. Although thermophilic Actinomycetes, similar to those in the moldy hay which causes farmer's lung, are also found in moldy sugar cane, the precise source and nature of the antigen have not been identified.

Other disorders in this category include bird-breeder's lung, mushroom-picker's lung, cheese-worker's lung, pituitary-snuff lung, bible-printer's lung, wheat weevil disease, maple-bark disease, suberosis (from oak bark) and sequiosis (from red wood dust). A recent addition is detergent-worker's lung, and the source of the antigen in the sensitizing detergent powder is said to be alcalase, an enzyme from Bacillus subtilis, although this has been disputed lately.

Some also include byssinosis, a hazard in the textile industry, but with less convincing evidence. The acute symptoms consist of shortness of breath, cough and fever, characteristically developing on Monday upon return to work but gradually subsiding later in the week. Continued exposure is aggravated by smoking and gradually leads to an impairment in ventilatory capacity and irreversible pulmonary changes. However, few deaths have been recorded. Although antibodies to antigens of the cotton plant have been found in the sera of many of these patients, desensitization to these antigens has not been an effective form of therapy. It has not been shown conclusively that byssinosis is primarily a reaction of hypersensitivity. A view of pathogenesis is that some dusts of the textile industry contain a substance capable of inducing bron-
chial and bronchiolar spasm by the non-
antigenic release of histamine. Unlike in 
cases of bronchial asthma, the patients with 
byssnosis are not hypersensitive to inhaled 
histamine. Not much is known about the 
pulmonary histopathologic changes in this 
disease.

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