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INDUSTRIAL HYGIENE AND TOXICOLOGY

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of aluminum by physicians for therapeutic or prophylactic purposes, makes only metallic aluminum available. Some investigators, notably Hannon,⁷³ have reported marked success in the treatment of patients with severe disability. However, when purely objective criteria have been used to measure disability the results have been somewhat less striking. Gardner, Dworski, and Delahant⁷⁴ have suggested that variations in response to aluminum therapy may be due in part to the nature of the dust that has caused the silicosis. They suggest that dust which is primarily free silica may react with aluminum more readily than dust which contains high percentages of iron. The use of aluminum generally in industry for the therapy or prophylaxis of silicosis should be contemplated only with the utmost caution.

I. ASBESTOSIS

Asbestos is a hydrated magnesium silicate. More than 90 per cent of the raw mineral used in this country and Great Britain is produced in the Canadian chrysotile mines. Asbestos is used in two general types of manufacturing processes. It may be used either by itself or mixed with other insulating materials such as diatomaceous earth for fireproofing, packing, or insulating; or it may be combined with cotton and woven as a textile for fireproof and heat-resistant clothing and other substances. Lanza⁷⁵ estimates that there are about 10,000 persons exposed to asbestos in the United States. Most observers feel that the incidence of asbestosis in American asbestos workers is quite low. Asbestosis has, however, been reported more frequently in England and Canada.

Lanza, McConnell, and Fehnel⁷⁶ concluded from their study of asbestosis that: Prolonged exposure to asbestos dust causes pulmonary fibrosis different from that produced in silicosis and demonstrable by roentgenogram. Clinically it appears to be milder than silicosis.

Definite cardiac enlargement frequently was found to be associated with asbestosis.

A predisposition to tuberculosis, due to asbestos dust, was not indicated although it was not known to what extent asbestosis may add to the mortality from pneumonia and acute nontuberculous pulmonary infections.

Symptoms. The onset of asbestosis, as of silicosis, is slow although symptoms are apt to be somewhat more marked than in silicosis. In silicosis there may be marked x-ray findings with little complaint of symptoms, whereas the opposite is likely to be the case in asbestosis. As in silicosis, dyspnea is the cardinal symptom. Anorexia occurs frequently in advanced stages, and cyanosis and clubbing of the fingers are apt to appear with greater constancy in asbestosis.

Pathology. The fibrosis in asbestosis is diffuse and tends to predominate in the basal portions of the lungs in contrast to the generalized nodular fibrosis of silicosis

⁷³ J. W. G. Hannon, *Trans. Can. Inst. Mining Met.*, 43, 180 (1944).

⁷⁴ L. U. Gardner, M. Dworski, and A. B. Delahant, *J. Ind. Hyg. Toxicol.*, 25, 211 (1944).

⁷⁵ A. J. Lanza, *J. Am. Med. Assoc.*, 106, 368 (1936).

⁷⁶ A. J. Lanza, W. J. McConnell, and J. W. Fehnel, *U.S. Pub. Health Repts.*, 50, 1 (1935)

with a predominance in the upper portions of the lung. Bronchiectasis and bronchiolectasis are frequent, especially in the more fibrous portions. Whereas the proliferation of fibrous tissue is caused by chemical action in silica exposure, it is induced by mechanical action in asbestos exposures. Gardner⁷⁷ found that the fibrosis-producing character of asbestos could be almost eliminated by grinding the fibers so that no particles more than $2\ \mu$ in length were present. As previously mentioned, asbestosis is classified among the inert dusts.

Microscopic Anatomy. Johnstone⁷⁸ described the microscopic appearance of the lungs somewhat as follows: in the early phases of the disease there is thickening of the alveolar septa which results from fibroblastic proliferation. The alveolar spaces contain numerous phagocytes. With progression of the disease fibrosis becomes more marked; the alveolar structure gradually disappears, and in its place there is now dense fibrous tissue. The few alveoli that remain in the area of fibrosis are lined with low cuboidal epithelium giving them an almost glandular appearance.

Scattered throughout the lung in both the diseased and healthy parts are spindle-shaped structures described first by McDonald.⁷⁹ These bodies are 20 to 100 μ in length and are bulbous on one or both ends so that they appear club- or dumbbell-shaped. They are brownish in color, do not stain, and give a Prussian-blue reaction for iron. Simson⁸⁰ has produced these bodies in guinea pigs by experimental exposure to atmosphere containing asbestos. Lynch⁸¹ concludes that these "curious bodies" signify exposure to asbestos dust but do not necessarily indicate asbestosis.

X-Ray Examination. For an excellent review of roentgenographic findings in both silicosis and asbestosis the reader might well refer to Pendergrass.⁸² Characteristic differences in the roentgenographic findings in silicosis and asbestosis are tabulated below:

Asbestosis	Silicosis
Fibrosis diffuse (film may have ground glass appearance from pleural involvement).	Fibrosis nodular.
Findings may be either bilateral or unilateral.	Findings characteristically bilateral.
Lesions largely in the lower one-half or two-thirds of the lung fields.	Lesions predominately in the upper two-thirds of the lung fields.
Emphysema in upper portion of lung fields.	Emphysema in lower portion of lung fields.

Control. Prevention of asbestosis depends entirely upon preventing exposure to concentrations of dust sufficiently high to produce the characteristic reaction.

⁷⁷ L. U. Gardner, *Lab. Med.*, 9, 45 (1910).

⁷⁸ R. T. Johnstone, *Occupational Diseases*, Saunders, Philadelphia, 1912.

⁷⁹ S. McDonald, *Brit. Med. J.*, 2, 1025 (1927).

⁸⁰ F. W. Simson, *Brit. Med. J.*, 1, 885 (1928).

⁸¹ K. M. Lynch, *J. Am. Med. Assoc.*, 109, 1947 (1936).

⁸² E. P. Pendergrass, "Roentgen-Ray Diagnosis in Silicosis and Asbestosis," in A. J. Lanza, *Silicosis and Asbestosis*, Oxford Univ. Press, New York, 1935.

Dreessen, DallaValle, Edwards, Miller, and Sayers²¹ have found evidence to indicate that 5,000,000 particles per cubic foot of air is a satisfactory figure for the maximum permissible atmospheric concentration of asbestos to which workers may be exposed. Definite permissible standards, however, have not been established.

VI. Dust Causing Minimal Fibrosis or No Fibrosis

Gardner²² has pointed out that any known inorganic dust other than free silica and the asbestos silicates may produce nonspecific dust reactions, as described on page 486. X-ray markings may be found in other conditions such as chronic infection and heart disease. No interference with pulmonary function or disability is produced by dust of this type and there is no influence on susceptibility to tuberculosis.

A. SILICATES

McCord,²³ from a number of sources, has compiled a list of the commonly used silicates, which is presented here:

Olivine—a magnesium silicate widely present in all basic rocks. Many varieties of this stone are known.

Calcium silicate—nonexistent in nature, but a common product of industry, may be found at blast furnaces and in production of cement and hydrated limes. Other silicates of calcium are known.

Willerite—a zinc silicate (rare).

Sodium silicate (water glass)—the well-known water-soluble silicate, commonly called water glass. This is widely used in industry, notably as a filler in soaps. This is the only crystalline silicate of sodium, the others being amorphous glass.

Tremolite—a magnesium-calcium silicate.

Asbestos—tremolite, actinolite, chrysotile, or amianthus, all of which are essentially magnesium silicates.

Jade—another form of magnesium-calcium silicate.

Crocidolite—"blue asbestos." It is a sodium iron silicate.

Talc—a hydrated magnesium silicate with extensive industrial application.

Serpentine—a form of talc.

Agalite—a variety of talc resembling asbestos. It is used in the coating of paper, and as a paper filler.

Mecrochloa—also called sepiolite. It is closely akin to talc.

Serpentine—hydrated silicate of magnesium. It is a common building stone.

Sillimanite—aluminum-containing silicate. The source of many stone tools of the stone age.

Topaz—a semiprecious stone of silicate origin. Chemically it is an aluminum fluosilicate.

Filler's earth—a hydrated silica-aluminum compound, associated with ferric oxide.

Kaolin (kaolinite)—many related silicates of mixed constituency.

Clays—hydrated aluminum silicates containing iron. Titanium, quartz and mica, are likely to be present in clays.

²¹W. C. Dreessen, J. M. DallaValle, T. I. Edwards, J. W. Miller, and R. R. Sayers, *U.S. Pub. Health Bull.* No. 241 (1938).

²²C. P. McCord, *Ind. Med.*, 2, 4 (1934).