11

OTHER PNEUMOCONIOSES

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ALUMINUM

It is now fairly well accepted that aluminum and its oxide may produce pulmonary fibrosis. The effects of aluminum on the lung tend to differ according to the composition of the inhaled aluminum-containing dust. Pulmonary fibrosis has been reported in workers involved in the manufacture of aluminum abrasives and also in subjects using aluminum powder in the manufacture of explosives.

Pulmonary Fibrosis Due to Inhalation of Bauxite (Aluminum Oxide)

This condition is commonly referred to as Shaver's disease and the first detailed report was published in 1947.[1] It occurs in workers who manufacture alumina abrasives, in particular, corundum. The latter is composed of aluminum oxide, is of great hardness, and is manufactured in special electrical furnaces. The process involves the grinding up of bauxite into a powder which is then intimately mixed with iron and coke. The mixture is placed in large iron pots into which carbon electrodes are lowered. The mixture is fused at over 2000° C. and during the process dense white fumes are given off which contain both aluminum oxide and silica. The fumes contaminate the atmosphere in the furnace rooms, although most escape through the openings in the roof.

Shaver and Riddell had each and separately encountered a few subjects with what appeared to be idiopathic pulmonary fibrosis associated with pneumothorax before they realized that all of their subjects worked in the same plant manufacturing abrasives. This observation prompted

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them to survey all the men employed at the furnaces of four plants which were involved in the manufacture of alumina abrasives. They found twenty-three subjects with radiographic abnormalities, of whom eight had had one or more spontaneous pneumothoraces.[1]

The symptoms of affected subjects are related to the degree of radiographic lung involvement. Shortness of breath is the most common complaint. Paroxysms of shortness of breath occur along with chest pain. Sputum production and cough are common; however, the sputum is usually mucoid. Tightness in the chest is frequent, as are weakness and fatigue. Pleuritic pain and acute shortness of breath, when they occur together, indicate the presence of a pneumothorax. An acute form of the condition occurs when exposure has been intense, and is characterized by cough, low grade fever, and chest tightness. In many subjects the acute condition progresses to the chronic disease.

Physical findings are nonspecific unless a pneumothorax is present. Tachypnea and cyanosis occur in advanced cases. Dullness to percussion may be present and basal crackles occur frequently. Finger clubbing is rarely if ever seen.

RADIOLOGY

The findings vary according to the severity of involvement, and the less severely affected subject may show little in the way of abnormality. Widening of the mediastinum and elevation of the diaphragm are frequent. Both lungs are usually affected by a diffuse reticulonodular process. As time goes by, numerous blebs appear and certain regions appear to be honeycombed. The upper lobes are most affected.[1]

The acute form of the disease is characterized by an acinous filling pattern; however, this often only partially resolves, leaving a reticulonodular pattern. Pneumothorax is common and may be chronic.

PATHOLOGY

Macroscopically the lungs appear solid and of a gray-black color with frequent pleural thickening and adhesions. Emphysematous blebs are usually observed on the pleural surface. The lungs feel fibrotic and are difficult to section. The upper zones are more affected. Dense fibrous masses may extend out from the hila.

Histologically in the acute stage there is often alveolar edema and thickened septa. The damaged alveoli become lined by epithelial cells and lymphocyte aggregation may be seen in the bronchioles. Interstitial fibrosis occurs later but classical silicotic lesions are absent. Vascular damage is slight.

The respective roles of alumina and silica in the production of the

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pulmonary changes are still the subject of debate but there is little doubt that many of the changes are induced by aluminum.

Fatal cases occur, and death is usually due to respiratory failure and concomitant pulmonary infection.

Aluminum Lung (Powdered Metal)

The first detailed report of the harmful effects of aluminum came from Goralewski.[2] He drew attention to the fact that German workers engaged in the manufacture of pyro-aluminum powder developed an acute respiratory illness, often within a few months of starting work. The powder was used for making explosives and hence was not coated with stearin, a substance which is often used in the manufacture of aluminum powder. The affected subjects had a cough, low grade fever, shortness of breath, lethargy, and anorexia. Their radiographs showed pulmonary shadows and in some a pneumothorax developed. Histological examination of the lungs revealed fibrotic changes. By 1956, ten of Goralewski's original eighteen patients had died.[3] Goralewski's material was confiscated during the British advance into Germany in 1945 and sent to the London Hospital where his findings were subsequently confirmed.

Because of the German experience, epidemiological studies were carried out on British workers involved in the manufacture of incendiary bombs and aluminum airplane propellers.[4] No pulmonary morbidity that could be attributed to aluminum was detected and, moreover, no explanation for the difference between the British and German findings was forthcoming. In 1959 Mitchell reported a subject with pulmonary fibrosis that appeared to be a consequence of aluminum exposure.[5] In 1961 additional subjects with pulmonary fibrosis were reported by Mitchell et al.[6] and by Jordan.[7]

Aluminum powder is produced in two forms: flake powder which is formed by stamping cold metal, and granulated powder which is prepared directly from the molten metal. An unusual form of flake powder known as "pyro" is composed of three-dimensional particles and is used in the manufacture of fireworks. The subjects reported by Mitchell et al. were all exposed to the flake variety of aluminum powder.[6] Their job was to first stamp aluminum into flakes. From the stamped powder, paint and "pyro" were made. To the powder used in the manufacture of paint, large quantities of stearin were added. This was not true of the pyro powder, in which as little stearin as possible was used. A small amount of carbon black was added to the pyro. The mixture was then stamped and ground into a fine blackish powder. During the filling and emptying of the stamping machines, large quantities of dust were liberated. Gravimetric samples of the dust in the room revealed mean concentrations of 95 mg. per cubic meter with most particles in the 1 to 2 microns size.

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Most of the dust consisted of metallic aluminum but an appreciable concentration of aluminum oxide and hydroxide was present. Small quantities of copper, magnesium, and carbon were likewise present.

Symptoms and Signs

These are essentially the same as those in Shaver's disease, namely cough, sputum, anorexia, and often pneumothorax. Signs are scanty, but basal crackles occur. As in Shaver's disease, clubbing is absent. Tachypnea, a small chest expansion, and the characteristic signs of a diffuse fibrosis are present in subjects with advanced disease.

In 1967, McLaughlin and co-workers reported a patient in whom pulmonary fibrosis and also encephalopathy developed which they attributed to the inhalation of aluminum dust.[8] The subject was a forty-nine year old man who had worked for 13 years in the ball mill of an aluminum powder factory. His pulmonary symptoms were minor; however, during life he had suffered from epilepsy and had developed a progressive encephalopathy. The lungs and brain were analyzed and found to contain twenty and one hundred twenty-two times the expected aluminum content, respectively.

Pathology

Macroscopically and microscopically the changes are similar if not identical to those seen in Shaver's disease. Interstitial fibrosis and epithelialization of damaged alveoli are common. Analysis of the lungs reveals "grossly" increased aluminum content.

Corrin in a series of experiments, some of which involved animals, demonstrated that stamped aluminum reacts vigorously with water while the granular powder is unreactive.[9, 10] He showed that the granular particles are inert because they are coated with inert aluminum oxide and thus do not react with water. The formation of aluminum oxide is prevented in the stamping process by the use of stearin. The sudden appearance of aluminum pneumoconiosis in Britain was attributed by Corrin to the substitution of mineral oil for stearin, for in contrast to stearin, mineral oil permits the powder to react with water.[9, 10] He also showed that it was the aluminum that was responsible for the fibrosis, and not the stearin, and that granular aluminum was much less fibrogenic.

ANTIMONY PNEUMOCONIOSIS

Antimony is closely related to arsenic and readily forms alloys with lead, tin, zinc, and iron. It occurs normally in several forms: stibnite

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(SbS_3), valentinite (Sb_2O_3), kermesite (Sb_2S_2O), and senarmontite (Sb_2O_3). It is mined in China, South Africa, Russia, Mexico, and Bolivia.

Antimony has been used in the manufacture and plating of vases since the times of the great Egyptian civilizations. Stibnite has also been used as a cosmetic. At present the metal is used as a constituent of alloys, in the compounding of rubber, in flame proofing, and in paints and lacquers. Antimony is also used in medicine as an emetic (tartar emetic) and in the treatment of schistosomiasis.

The dust that is produced during the mining of antimony often contains some free silica, and the term silicoantimonosis has been coined to refer to the condition of lungs containing both silica and antimony. The antimony ore, when it is processed, is pulverized into a fine dust. High dust concentrations are thus present during the operations of reduction and scaling. Crushing of the ore generates coarse particles which are not retained by the lungs, and many of the other processes are wet and relatively dust-free. However, furnacemen who refine the metal prior to its being alloyed with other metals are exposed to appreciable concentrations of antimony dust.

Antimony pneumoconiosis has been described in men working with stibnite.[11] The latter is usually emptied from bags through a grill onto a tating kiln. The metal is volatilized by the heat and forms a fine white powder at the top of the kiln which escapes into the surrounding atmosphere.

Antimony enters the body through the lungs and skin. The metal is absorbed from the lung parenchyma, is taken up by the blood and tissues, and is excreted in the feces. Some remains in the red blood cells. The inhalation of antimony may produce rhinitis, bronchitis, and nasal septal perforation. Conjunctivitis and dermatitis occur.

Although antimony may produce radiographic changes in the lung (Fig. 11–1), pulmonary function does not appear to be affected.[12] Massive fibrosis has not been reported and what few pathological studies are available suggest that the inhalation of antimony does not produce fibrosis.[13, 14]

BAKELITE PNEUMOCONIOSIS

The recent description of two subjects with generalized pulmonary infiltration and exposure to bakelite raises the possibility that the inhalation of the latter may occasionally lead to a specific pulmonary disease.[15] Although Pimentel states that the clinical features of bakelite pneumoconiosis resemble those of extrinsic allergic alveolitis, it is apparent from his description that the symptoms differ from those usually seen in this condition, namely, the sudden onset of fever, chills, and shortness of breath. According to Pimentel, the basic lesion is an epithe-

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Figure 11-1 Chest radiographs of subject with antimony pneumoconiosis. (Courtesy of Dr. E. P. Pendergrass.)

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hoid granuloma resembling sarcoid, and again this differs to some extent from the usual histological changes that are seen in bagassosis and farmers' lung. He claims that the lung shows characteristic inclusions which give the chemical reactions of phenol compounds. Despite the fact that Pimentel claims to have developed an animal model for the disease, his description is far from convincing and the existence of bakelite pneumoconiosis must remain sub judice.

BARITOSIS

Baritosis was first described by Arrigoni among baryta miners in Italy.[16, 17] It results from the inhalation of respirable particles of barium sulfate. More recently a few workers in a lithopone plant in Pennsylvania were found to have abnormal chest radiographs.[18] One man had some distinctive features in his chest radiograph that resembled closely those previously described in the baryta workers by Arrigoni. Further in-

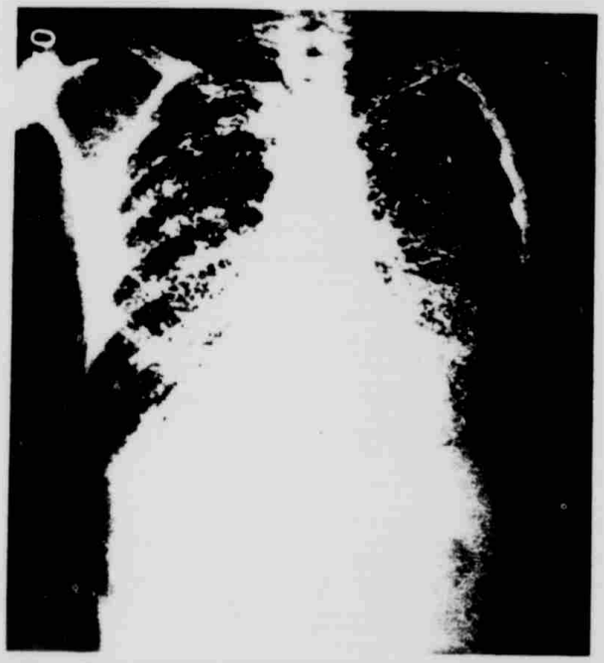


Figure 11–2 Chest radiograph of subject with baritosis. (Courtesy of Dr. E. P. Pendergrass.)

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quiries showed that the men in the lithopone plant were exposed to finely dissolved barium sulfate powder.

Baritosis is not associated with respiratory symptoms or impairment as far as is known. The radiographic appearances are quite striking (Fig. 11–2). The deposits of barium appear as multiple extremely dense small rounded opacities.[18, 19] At autopsy the lungs appear grayish and are full of small discrete nodules. Fibrosis is not a feature of the condition unless there have been other respiratory exposures.

BERYLLIOSIS

Beryllium is a rare element that was discovered by Vanquelin in 1797. About fifty different minerals contain beryllium, but of these beryl is of prime importance. Beryl is beryllium aluminum silicate and yields about 12 per cent of the oxide and around 4 per cent of the metal. Most of the ore comes from South America and the cost although fluctuating is well over a hundred dollars per pound. Beryl is also found in Argentina, Brazil, India, Rhodesia, and South Africa. In the United States there are deposits in Colorado, New Mexico, and Utah. Bertrandite is a low grade ore which is found in Utah and is currently being mined.

Beryllium is a metal that is in demand because of its lightness and tensile strength. Since it is nonmagnetic and transmits x-rays easily, beryllium was extensively used as an alloy in combination with steel, aluminum, and copper, and it was also used in the manufacture of fluorescent lighting tubes. However, the recognition of berylliosis led to its replacement by other less toxic substances. Its main uses at the present time are in nuclear physics since it reduces the speed of fission reactions, in the space program, and as a "window" in x-ray tubes.

Production of Beryllium

Two processes are used to extract beryllium from the ore. These are known as the sulfate and fluoride extractions. In the former crushed beryl is melted in an arc furnace at 1650° C. and poured through a high-velocity water jet to form "frit." Following heat treatment, the frit is pulverized in a ball mill, and then mixed with concentrated sulfuric acid. This mixture, known as a slurry, is then sprayed onto a revolving sulfating mill. The beryllium is now in water-soluble form and can be separated or leached from the sludge. Ammonia is added to the leached liquid which is then transferred to a crystallizer in which ammonium alum is crystallized out. The liquor is next treated with chelating agents to hold iron, nickel, and other metals in solution. Sodium hydroxide is added and this forms sodium beryllate. The latter is hydrolyzed so that

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beryllium hydroxide is precipitated. Beryllium hydroxide can be easily converted to metallic beryllium or to beryllium salts.

The fluoride process involves sintering in a rotating furnace a mixture of beryl, sodium silicofluoride, and soda ash. The sintered residue is pulverized, melted, and separated by leaching. Sodium hydroxide is added to the solution of beryllium fluoride that has been formed by leaching. This leads to the precipitation of beryllium hydroxide which can then be treated as described in the sulfate process.

Several beryllium salts are used industrially. They are: (1) beryllium fluoride (BeF_2), (2) beryllium chloride ($BeCl_2$), (3) beryllium nitrate ($Be(NO_3)_2 3H_2O$), and (4) beryllium sulfate hydrate ($BeSO_4 4H_2O$).

Aside from health hazards, beryllium is inflammable and its degree of inflammability is related to its particle size.

Effects of Beryllium

Beryllium is highly toxic and leads to a condition known as berylliosis. The metal may be absorbed either through the lungs or the skin, especially if the latter is not intact. The metal is not absorbed to any extent by the gastrointestinal canal. Although the metal has local effects, these are relatively unimportant compared with the systemic changes that also may occur. Some beryllium compounds are absorbed more rapidly than others. Once in the body, beryllium combines with a protein [illegible] is deposited in the liver, spleen, and bones. A small residue remains [illegible]he lungs. The rate of urinary excretion of the metal depends on how rapidly and in what form the metal has been absorbed. Beryllium persists in bone and liver long after it has been entirely excreted by the lung.

Effects on Skin

It is important to bear in mind that aside from the pulmonary effects of beryllium, the skin is also often affected.[20, 21] Erythematous papular or vesicular rashes occur on the exposed parts of the body. They are usually itchy and they develop after an "incubation" period of about two weeks. Accidental implantation of the metal in the skin may produce a "beryllium ulcer" or granuloma. Such ulcers are often chronic. Chronic pulmonary berylliosis may undergo an acute exacerbation when the afflicted subject's skin comes into contact with the metal or its salts. Conjunctivitis is also seen and may occur in association with the pulmonary and cutaneous effects. There is some evidence to suggest that the cutaneous manifestations of beryllium exposure are related to hypersensitivity and that sensitization has to occur first. The more soluble the salts are, the more likely is sensitization to occur, and the metal itself is thought not to

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produce sensitization if the skin is intact. Beryllium fluoride is the most potent sensitizing agent, followed by beryllium chloride and sulfate.

Acute Berylliosis

The acute syndrome affects the nasopharynx, trachea, bronchi, and lung parenchyma.[20, 22] The mucous membranes of the nose are hyperemic and swollen. Ulceration may be present and nasal septal perforation occurs. Tracheitis and bronchitis lead to a dry irritative cough. Substernal pain is common. If the exposure to beryllium is severe and intense, a chemical pneumonia develops. The patient complains of the sudden onset of shortness of breath. He rapidly becomes ill, and death is not uncommon. Physical examination reveals cyanosis, tachycardia, and tachypnea. Fever is unusual unless secondary infection occurs. Crackles are often present, especially in the mid to low portions of the lungs. Chest film may show an appearance that suggests pulmonary edema. In some instances, the radiographic picture resembles that of an acute miliary process, while in others a patchy acinous filling process is present. If the process develops more slowly, weight loss and anorexia are common.

During the acute process, the patient may be severely desaturated, his lungs are stiff, and he has a low diffusing capacity. The blood count is normal.

Treatment consists of giving supplementary oxygen, preferably by mask or nasal catheter. Only if the arterial oxygen cannot be maintained above 40 mm. should mechanical ventilation be considered. Antibiotics are useful in preventing secondary infection, and a combination of penicillin and streptomycin is probably the most effective. Steroids should be given in high doses, although there is no conclusive evidence that they are effective. Most of the changes found in acute beryllium pneumonitis resolve completely within one to four weeks, but in around 10 per cent of affected subjects chronic berylliosis develops. In the subjects who have died of this condition, the lungs resemble those seen in acute pulmonary edema. The alveoli are filled with fibrin and red cells, while the alveolar walls are infiltrated with lymphocytes and plasma cells. The trachea and bronchi may show acute tracheitis and bronchitis. Epithelialization of the alveolar nodes and organization of the exudate may be seen.

Chronic Pulmonary Berylliosis

This is a systemic disease which produces granulomata throughout the body but particularly affects the lungs. The disease was described by Hardy and Tabershaw in 1946.[23] Most of the early case reports were of workers engaged in the manufacture of fluorescent strip lighting; however, in some instances contact was much less close, and indeed wives of beryllium workers have been reported to incur the disease by inhaling

the beryllium dust from their husbands' clothes. The ambient air around beryllium refineries may contain enough beryllium to lead to the development of chronic berylliosis.[24, 25] Women seem to be more often affected than men. In many instances there is a latent period of 10 to 15 years following exposure before the disease appears.[26] Although beryllium is no longer used in the manufacture of fluorescent bulbs, there are still two large beryllium refineries in the United States, and sporadic cases of berylliosis are still occurring and are likely to continue to do so.

Clinical Features. Needless to say, a history of exposure to beryllium is necessary, but it is important to remember that berylliosis is not limited to workers in beryllium refineries (vide supra). The onset of symptoms may occur long after exposure has ceased, and it is therefore important to take a complete occupational history.[26] Symptoms of the chronic condition often develop at a time of stress, viz., during pregnancy or following surgery. At first minimal, the dyspnea tends to become progressive and unremitting. A dry unproductive cough is common and skin lesions may also be present. There may also be a history of previous acute beryllium pneumonitis. In the established case of chronic berylliosis, there is tachypnea, a small tidal volume, and the typical physical signs found in a diffuse fibrosis. Weight loss and fatigue are also frequent.

Unfortunately, almost all of the clinical features of berylliosis are also found in sarcoidosis.[27, 28] Thus lymphadenopathy, especially hilar, occurs in both conditions, although generalized lymphadenopathy is less common in berylliosis. Hilar adenopathy in the absence of pulmonary changes is rare in berylliosis but common in sarcoid. Granulomatous skin lesions are likewise common to berylliosis and sarcoidosis. Hepatic and splenic involvement occur in both diseases and the spleen may be palpable in both. Salivary gland enlargement and cystic bone changes are felt by some to be peculiar to sarcoidosis. Nephrocalcinosis and hypercalcemia occur in both conditions and their presence offers no help in distinguishing them. Meningitis, peripheral neuropathy, and involvement of the myocardium have not been reported in berylliosis, but since they are such rare complications of sarcoidosis they are usually little help in the differential diagnosis. Ocular involvement such as uveitis is peculiar to sarcoid. Uveoparotid fever is not seen in berylliosis, nor is there a change in tuberculin reactivity. Remission is also much more common in sarcoidosis.

Chronic berylliosis is often accompanied by abnormalities of the serum proteins and in this, too, resembles sarcoidosis. The gamma globulin production is predominantly affected; however, in chronic berylliosis, unlike sarcoidosis, the IgG fraction is primarily involved, and is elevated in most subjects.[29] Unfortunately it is also elevated in beryllium workers who have no clinical evidence of acute or chronic berylliosis.

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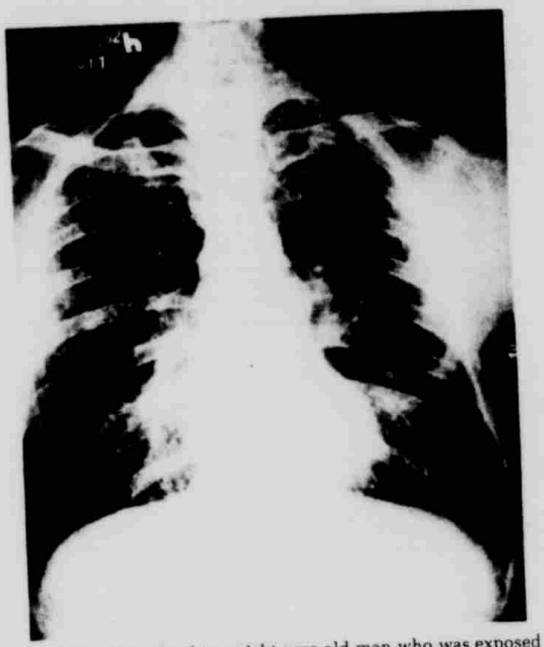


Figure 11–3 Chest film of a thirty eight year old man who was exposed to beryllium. There is a fine reticulonodulation present in both lung fields, with bilateral hilar adenopathy. He had no pulmonary function abnormalities other than slight oxygen desaturation on exercise. (Courtesy of Dr. Howard Van Ordstrand.)

Neither are there blood changes specific to either sarcoidosis or berylliosis.

As the disease progresses the patient becomes increasingly dyspneic. His respiratory rate climbs, his arterial oxygen partial pressure falls, and he becomes cyanosed. Clubbing may develop. As pulmonary scarring and bleb formation develop, the likelihood of pneumothorax increases. A few scattered rhonchi may be heard and there may be some scattered basal crackles. Gradually cor pulmonale develops and right ventricular hypertrophy becomes evident clinically and electrocardiographically. Progression of the disease is slow and a survival time of fifteen to twenty years is relatively frequent.

Radiographic Features. The radiographic features of berylliosis are nonspecific. In some instances, radiographic changes may precede the development of symptoms by several years. Both lungs are commonly affected and there is usually a miliary mottling throughout. Hilar adenopathy is a frequent accompaniment (Fig. 11–3). Larger blotchy coalescent infiltrates are also seen and closely resemble those seen in sarcoidosis. In longstanding berylliosis, the lungs become small and

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show widespread reticulonodulation. In some subjects extensive honeycombing occurs.

Pulmonary Function Abnormalities. These too are entirely nonspecific and are those seen in other diffuse fibroses including sarcoidosis.[30-32] Typically there is an increased respiratory rate and a reduced tidal volume. The vital capacity, total lung capacity, and residual volume all are decreased but the former is usually most affected. There is arterial desaturation, a slightly low arterial P_{CO_2}, but a relatively normal pH. The lungs are stiff, and the static compliance is reduced. Elastic recoil pressure at total lung capacity is increased. Late in the course of the disease when cor pulmonale supervenes, minor degrees of airways obstruction may develop. The diffusing capacity is reduced and serial measurement of this function offers the best means of following the course of berylliosis.

Other Diagnostic Tests. A cutaneous test for berylliosis was first discovered by Curtis in 1951.[33] The beryllium patch test is often, but by no means invariably, positive in chronic berylliosis. A positive patch test is probably a consequence of delayed hypersensitivity to beryllium. The test is best done with a piece of gauze or filter paper soaked in 1 or 2 per cent beryllium fluoride, sulfate, or nitrate. Metallic beryllium cannot be used for patch testing. A positive reaction is recognized by the development of an erythematous papule in two to three days. Sneddon biopsied the site of the reaction and showed sarcoid granulomata to be present.[34] There is some evidence that patch testing may lead to an exacerbation of the pulmonary symptoms and to a decrement in pulmonary function.[34, 35] The test is negative in sarcoidosis, and although often positive in chronic berylliosis, it may be negative. In contrast, the Kveim test, being negative in berylliosis, may be helpful in differentiating the conditions.[36]

Tissue biopsy and spectrographic analysis of the biopsy specimens for beryllium are singularly unhelpful.[37] Most workers who have been exposed to beryllium for any appreciable period will be found to have beryllium present in their bodies. If the exposure is recent, it may be present in the lungs and urine. However, beryllium persists in the bones and liver for many years, and there may be an increased beryllium content of these organs even though the worker has not been exposed for many years. Spectrographic analysis cannot confirm the presence of the disease since the presence of an excess of beryllium in the tissues is found in most subjects who have at some time in their life worked in a beryllium refinery. Moreover, the severity of chronic berylliosis is unrelated to the beryllium content of the tissues. Similarly, a lung biopsy specimen may have a normal beryllium content when there is excellent circumstantial evidence to suggest the presence of berylliosis.

Pathology. Chronic berylliosis is characterized by the presence of noncaseating granulomata.[38] These are indistinguishable from those seen in sarcoidosis. Round cell infiltration is common but necrosis is rel-

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Figure 11–4A. Medium power photomicrograph of an open lung biopsy specimen. Granulomatous interstitial pneumonitis is present, with obvious giant cells. The beryllium content of the lung was 1.3 micrograms per 100 grams of tissue. (Courtesy of Dr. Howard Van Ordstrand.) B. Chronic beryllium disease with interstitial fibrosis, lymphocytic infiltration, an occasional giant cell and several Schaumann bodies (top left). The patient died of pulmonary fibrosis in 1972, having worked at manufacturing fluorescent lights from 1942 to 1949. This is not the same patient as in A.

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atively rare (Fig. 11–4). Asteroid and Schaumann's bodies may be present. Blebs form late in the disease and may rupture, leading to a pneumothorax. Pleural thickening is usual. Right heart hypertrophy occurs late in the course, as do pulmonary vascular changes.

Treatment. Steroids are felt to improve the clinical condition of the patient, although there is no evidence that they have ever produced a cure. When starting treatment of a subject with berylliosis, it is probably best to use a large dose for about a week (75 mg. prednisone daily). This should be gradually tapered till the subject is taking the least possible dose to control his symptoms, viz., around 10 to 20 mg. daily. The effects of steroids are difficult to assess, mainly because of the euphoria they induce. Thus the patient is best followed by serial and objective pulmonary function tests, e.g., diffusing capacity measurements.

Pathogenesis. Despite the best and most extensive diagnostic studies, a differentiation between berylliosis and sarcoidosis may not be possible. Sarcoidosis can occur in subjects employed in a beryllium refinery and conversely berylliosis occurs in those who have never set foot in a refinery. Thus there is little doubt that some patients who have been diagnosed as having chronic berylliosis probably had sarcoidosis, and it is equally probable that other cases of so-called sarcoidosis were berylliosis. Some recent work carried out by Marx and Burrell suggests that the differentiation between the two conditions may soon become possible. These workers sensitized guinea pigs by repeated intradermal injection of beryllium sulfate.[39] They were able to produce classical delayed hypersensitivity. They then related the skin hypersensitivity to migration inhibitory factor (MIF) and showed a 74 per cent correlation. The sensitivity to beryllium could be transferred by cells. Lymphocytoxin was also demonstrated in the cells of the sensitized but not in those of the unsensitized animals. Subjects with chronic pulmonary berylliosis were assessed for sensitivity by in vitro inhibition of peripheral blood leukocyte migration and showed MIF production when exposed to beryllium sulfate in vitro.

Cellular and immune mechanisms of berylliosis have also been studied by Deodhar and co-workers.[40] They studied blast transformation of lymphocytes in subjects with berylliosis in the presence of beryllium sulfate in tissue cultures. Of their thirty-five patients, approximately three fifths showed blast transformation. The clinical severity of the disease appeared to be related to the degree of blast transformation. In about half of their subjects the serum IgA was reported to be significantly elevated. The findings contrast with those of Resnick et al. who found that it was the IgG fraction of the immune globulins that was elevated.[29] Since most of the subjects included in the series of Deodhar and co-workers were on steroids, and since steroids inhibit blast formation, the authors expressed the opinion that their results provide strong evidence that the etiology of berylliosis is related to immune mechanisms.[40]

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Prevention. All unnecessary beryllium exposure must be avoided. Dust control is of paramount importance so that the generation of fumes and dust is kept to a minimum. Wet processes should be used and the various work areas of the plant should be self-contained as far as possible. Beryllium-containing preparations should be transported as liquids rather than powders. Masks and protective clothing should be worn when concentrations of beryllium in the ambient air are much above the threshold limit value. Nonetheless, it must be realized that even with optimal care, the concentration of beryllium in the air may be sufficient to induce hypersensitivity in some subjects.

The beryllium content of the ambient air should be measured daily. It is recommended that exposure should not exceed 2 micrograms per cubic meter of air averaged over an 8 hour period. To protect against the acute form of berylliosis it has been recommended that a concentration of 25 micrograms per cubic meter of beryllium should never be exceeded.[41] Even so, there is good evidence to show that sporadic cases of berylliosis will occur despite the fact that exposures have been below the threshold limit value. Such cases are a consequence of the fact that berylliosis is a hypersensitivity disease and that minimal exposures are often sufficient to induce a hypersensitive state.

Pre-employment and periodic medical examinations of all workers in beryllium refineries are desirable. Such examinations should include determination of the vital capacity, the forced expiratory volume, and the flow rates. If possible the total lung capacity should be measured. Serial chest radiographs at intervals of a year are also helpful in controlling the disease.

CERIUM PNEUMOCONIOSIS

Cerium oxide is a rare earth which is used in the optical industry, in the manufacture of glassware and in metallurgy. A recent report from the La Rochelle district of France described two subjects with a miliary process, possibly due to the inhalation of cerium oxide.[42] The subjects had been exposed for eleven and fifteen years, respectively. No description of any pulmonary function abnormalities was provided, and there is no evidence that any occur.

GRAPHITE AND CARBON PNEUMOCONIOSIS

The term graphite is derived from the Greek word "to write." Graphite occurs in three forms: lump, amorphous, and flake. It is also known as plumbago or black lead, and is found almost all over the world; however, it is extracted or mined in Austria, Russia, Ceylon (Sri Lanka), Norway, and Korea. Lump graphite is found in veins that traverse ig-

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neous rocks. Quartz, feldspar, mica, and other impurities often occur in the veins. Lump graphite is usually removed by underground mining. Amorphous graphite occurs in underground beds often lying between strata of shale, sandstone, or quartz-containing rocks. It is excavated by blasting, and then is hand loaded into wagons prior to being brought to the surface. Flake graphite more often occurs near the surface as outcrops from sedimentary rock. This form of graphite is removed by the same methods as are used for open cast (strip) coal mining.

Small traces of free silica are found in most samples of graphite. After the graphite has been mined, the silica is removed by treating it with hydrofluoric acid and sodium hydroxide. The graphite is then ground, screened, and dried in kilns prior to use. It is used mainly in the manufacture of steel, lubricants, lead pencils, nuclear reactors, and electrodes. Since it conducts electricity, it is often used in generator brushes. Before graphite can be used in any of the above processes, it has to be crushed, ground, and milled to a fine powder. It is also used in electrotyping, a method used in the printing industry for duplicating plates. The exact process is described in detail by Gaensler and his colleagues.[43]

It has been known for many years that the inhalation of carbon may induce radiographic changes.[44-46] The changes are usually described as a fine basal reticulation or in some instances nodulation. The prevalence of carbon pneumoconiosis varies, but Meiklejohn found it in more than half the workers in two carbon plants.[47] While progressive massive fibrosis was first described in German carbon electrode workers,[48] Watson and his colleagues have described similar findings in England.[49] The latter workers found both simple and complicated pneumoconiosis occurring in carbon-exposed workers. The complicated form was accompanied by massive fibrosis, cavitation, and right ventricular hypertrophy. Similarly, simple pneumoconiosis of carbon workers was pathologically indistinguishable from coal workers' pneumoconiosis and the condition was characterized by the typical macule and the presence of focal emphysema. Even in subjects with progressive massive fibrosis, the silica content of the lungs was no greater than that found in the lungs of normal subjects. The British and German observations of both simple and complicated pneumoconiosis occurring in non-silica-exposed carbon electrode workers militate strongly against the silica theory of progressive massive fibrosis. Other case reports have emphasized the low silica content found in both forms of carbon pneumoconiosis.[50, 51]

It is felt by some that graphite modifies the fibrogenic action of silica.[52] Thus, while heavy exposure to pure carbon may induce a slight scattered fibrotic reaction, comparable exposures to a mixture of carbon and silica will induce the formation of nodular foci. In the latter instance, it is thought that the large amounts of carbon dust probably overwhelm the clearing mechanisms so that the silica persists in the lung and thereby

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has an opportunity to induce a fibrogenic response. Adequately controlled studies of the pulmonary function abnormalities that occur in carbon pneumoconiosis are not available. While individual case reports abound, in many instances it is difficult to demonstrate a cause and effect relationship between the physiological impairment and the presence of the pneumoconiosis. In some instances, the respiratory impairment is better explained by the presence of concomitant and coincidental obstructive airways disease. Nonetheless, a variety of pulmonary function abnormalities have been reported.[43] These include alveolo-capillary block (diffuse fibrosis), restrictive disease, and also obstructive airways disease. One of Gaensler's subjects had massive fibrosis with severe vascular changes and pulmonary hypertension.[43] Analyses of the lungs in three of his subjects revealed no silica in two instances, and 5 per cent cristobalite in the third. In short, it seems likely that carbon pneumoconiosis produces exactly the same effects on pulmonary function as does coal workers' pneumoconiosis. These are catalogued in detail elsewhere (Chapter 10).

HEMATITE PNEUMOCONIOSIS (SILICOSIDEROSIS OR MIXED DUST FIBROSIS)

The inhalation of relatively pure iron is dealt with in the section on siderosis; however, many iron miners are exposed not only to iron oxide, but also to a fair quantity of free silica. This leads to a condition known as silicosiderosis, or mixed dust fibrosis. It is seen in the iron miners of Cumberland (England), in the Siegerland miners of Germany, and in the Italian miners of Bergamo. Silicosiderosis seldom occurs without at least ten years' exposure, and most of the affected subjects have worked in the mines for at least twenty to thirty years.

The first adequate pathological description of the condition was given by Stewart and Faulds.[53] They noted a predominance of diffuse rather than nodular fibrosis, although the latter was present in certain instances. In the diffuse variety of fibrosis, the whole lung is brick red and there is often what appears to be associated focal emphysema. Radiographically, diffuse fibrosis appears as a reticular pattern. The nodular type of silicosiderosis is characterized by the presence of nodules similar to those seen in silicosis; however, in this instance they are red and are located predominantly in the upper lobes. The remainder of the lung appears brick red.

Massive fibrotic lesions may also be seen. Like progressive massive fibrosis of coal workers, the masses are usually situated in the upper lobes. They encroach on the blood and bronchial supply of the affected region and often undergo cavitation. The presence of massive fibrosis in silicosiderosis appears to be closely related to the silica content of the

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lung, and tuberculosis is a frequent complication. Microscopically the alveolar walls often show aggregated particles of hematite and silica. Other aggregates occur close to the blood vessels and alveolar septa. Peribronchiolar and periarteriolar fibrosis are frequent. Many of the silica and hematite particles are picked up by macrophages and transported in the lymphatics to the regional lymph nodes. Whorled nodules may develop in and along the lymphatic routes. The massive fibrotic areas appear to consist of dense collagenous tissue, heavily impregnated with iron and silica. The adjacent vascular supply is damaged and endarteritis obliterans is common. There is good evidence that cancer of the lung is found more often in Cumbrian iron miners; however, the cause of the increase is not known.[54] Two theories exist: the first, which seems more probable, relates to the excess radioactivity to which the miners are exposed. In this, it is thought to resemble the radiation-induced lung cancer that occurs in uranium miners. The second theory postulates that the iron ore contains a carcinogenic agent.

The symptoms and signs of silicosiderosis are relatively nonspecific. The miner often complains of shortness of breath, cough, and reddish brown sputum. The shortness of breath is worst in miners who have massive fibrosis, and many of them develop pulmonary hypertension and cor pulmonale.

Ochre miners also develop silicosiderosis. Ochres are brown-yellow earths that are used in the manufacture of pigments and colors. They are hydrated ferric oxides and are often contaminated with clay, silicates, and a certain amount of free silica. Ochre miners may have reticular and nodular radiographic changes, but massive fibrosis rarely if ever occurs.[55]

Foundry workers are exposed to both iron and silica, but the proportion of free silica to which they are exposed varies greatly according to their job. While it is undoubtedly true that many foundry workers inhale relatively pure iron and hence are not affected by pulmonary fibrosis or respiratory impairment, in a minority appreciable fibrosis occurs owing to the free silica to which they have been exposed. Mixed dust fibrosis is commonly seen in foundry welders and burners.[56] The nodule of mixed dust fibrosis differs macroscopically and microscopically from that seen in classical silicosis. The arrangement of reticulin and collagen fibers is linear or radial rather than concentric, and the outline of the nodule is irregular or stellate.[57] The mixed-dust nodule resembles more closely the coal macule than the typical silicotic nodule. Analysis of the lungs of foundry workers shows that free silica, silicates, and iron are found in varying proportions. The amount of fibrosis is in general related mostly to the free silica content. The radiographic appearances of mixed-dust fibrosis are indistinguishable from those seen in classical silicosis and silicosiderosis.

Boiler scalers who clean the water tubes and flues of boilers may

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also develop pneumoconiosis. This is usually a mixed-dust reaction, since the dust to which they are exposed contains free and combined silica, iron, carbon, and various carbonates. The scale of many marine boilers contains a high proportion of silica, viz., 8 to 10 per cent total silica.[58] Thus, dust exposures in iron and steel workers are usually of the mixed variety, and range from pure siderosis at the one extreme to pure silicosis on the other. Most, however, are mixed exposures, and aside from iron, silica, silicates, and numerous other potentially harmful dusts may be inhaled. In some instances, significant exposures to chromium oxide and nickel oxide also occur.[59]

PNEUMOCONIOSIS OF LAUNDRY WORKERS

A few subjects who were employed as laundry workers in the pottery district of Britain have been reported as developing pneumoconiosis. It is thought that these cases arose from the practice of laundry workers shaking out pottery workers' overalls prior to putting them in the wash. No evidence of pulmonary impairment was found in the afflicted subjects.[60]

SIDEROSIS

The condition of siderosis was described by Zenker in the late nineteenth century.[61] The two subjects he reported also had pulmonary tuberculosis, and it can be assumed that the fibrosis which he found in their lungs was more likely the result of tuberculosis than a response to the dust to which they had been exposed. Iron when inhaled in its pure form does not lead to fibrosis; however, it is often inhaled in conjunction with other fibrogenic dusts such as silica.

Siderosis is seen in its purest form in arc welders, oxyacetylene cutters, and silver finishers. During arc welding and oxyacetylene cutting, iron is melted and boiled by the heat of the arc or torch. The iron is emitted as particles of ferrous oxide which are immediately oxidized to ferric oxide and appear as blue-gray fumes. Prolonged inhalation of these fumes can lead to the development of radiographic changes in the lung that are identical to those seen in silicosis.[62, 63]

Silver finishers use what is known as jeweler's rouge to polish their unfinished wares. The rouge is composed of iron oxide and is often applied with a "buffer" that generates a cloud of small iron and silver particles.[64] The iron miners of Cumberland in Great Britain are subject to silicosiderosis, a condition which is accompanied by fibrosis and other pathological changes that are not seen in subjects exposed to pure iron.

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The same is true of the Italian iron miners from Bergamo. Similar changes have been observed in ochre workers.

Welder's siderosis was described by Doig and McLaughlin in 1936.[62] Since its original description, siderosis has generally been assumed to be benign and unassociated with respiratory symptoms. The bases for this assumption have been, firstly, the published statistics of mortality and morbidity in the United States and Britain;[65, 66] secondly, the lack of fibrosis in the lungs of welders;[63, 67] and thirdly, the absence of pulmonary function abnormalities in subjects with marked radiographic abnormalities.[67] Over the past few years there have been several reports of subjects with welders' siderosis who have had both symptoms and impairment of lung function. These reports assumed a cause and effect relationship between occupation and respiratory impairment.[68-70] Such inferences have been based on "a posteriori" reasoning. Histological examination of the lungs of these subjects has demonstrated both fibrosis and not infrequently emphysema. The presence of these conditions has been attributed to the inhalation of substances other than iron that are often present in the welding fumes. Such substances may be present as impurities in the metal being welded, or as constituents of the electrode. Included among them are carbon, manganese, aluminum, silicates, and also some free silica. Arc welders, especially those involved in welding aluminum, may also be exposed to ozone in concentrations up to 6 to 9 p.p.m., and exposures of this magnitude can lead to pulmonary symptoms and bronchitis.

While it must be conceded that other fibrogenic substances may be inhaled during welding, is it correct to assume that any respiratory impairment that is found can be assumed to be a consequence of the man's occupation? Welders are subject to all the diseases that the general population suffers from, and only by excluding these is it possible to incriminate welding as a cause of chronic respiratory impairment. Thus it has been suggested that welders are more prone to pneumonia than is the general population,[71] but confirmation of this is difficult.[65, 66] There is, however, little doubt that welding and also oxyacetylene cutters are prone to metal fume fever.[71]

Pathology

The first descriptions of the pathological effects of iron were recorded by Harding et al.[63] These workers described the pathological findings in four arc welders and an oxyacetylene cutter who came to autopsy. Some of these subjects had been exposed to silica and in them there was evidence of a mixed dust fibrosis. The lungs of the cutter showed no fibrosis at all. Harding and his co-workers attributed the fibrosis not to iron oxide, but to other constituents of the welding fumes,

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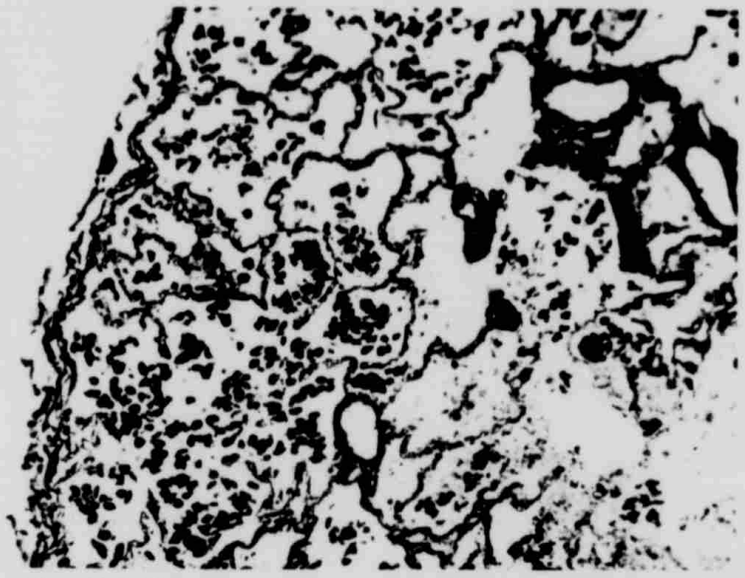


Figure 11–5 Photomicrograph of lung biopsy of subject with welders' siderosis. There is an absence of fibrosis; however, aggregated deposits of iron are much in evidence. Occasional alveolar walls can be seen to be disrupted, but these appearances are due to artifacts introduced in the preparation of the slide. Verhoeff's elastic stain, × 180. (From Morgan, W. K. C., and Kerr, H. D.: Pathologic and physiologic studies of welder's siderosis. Ann. Intern. Med., 58:293, 1963. Reproduced by permission.)

viz., silica and possibly some of the gases evolved such as the oxides of nitrogen.

Autopsy studies of silver finishers have shown an absence of fibrosis,[64] and chemical inhalational experiments in animals have similarly shown a lack of fibrosis in animals exposed to iron.[72] Morgan and Kerr described seven subjects with welders' siderosis, four of whom had had lung biopsies.[67] The histological appearances of the biopsied lung showed that while some iron lies free in the alveoli and respiratory bronchioles, most is taken up by the macrophages and can be seen in the lymphatic channels (Fig. 11–5). Fibrosis was not seen except in subjects with mixed-dust exposures. Analysis of a portion of one subject's lung revealed an iron content of 46 mg. of iron per gram of dry lung, this being fifteen times greater than the normal level. Despite the greatly increased iron content, no fibrosis was present. Another subject whose lung biopsy showed fibrosis was known to have a mixed-dust exposure, and an excess of silica was found in his lung. While the usual radiographic appearances of arc welder's lung are those of simple silicosis, exceptionally a massive

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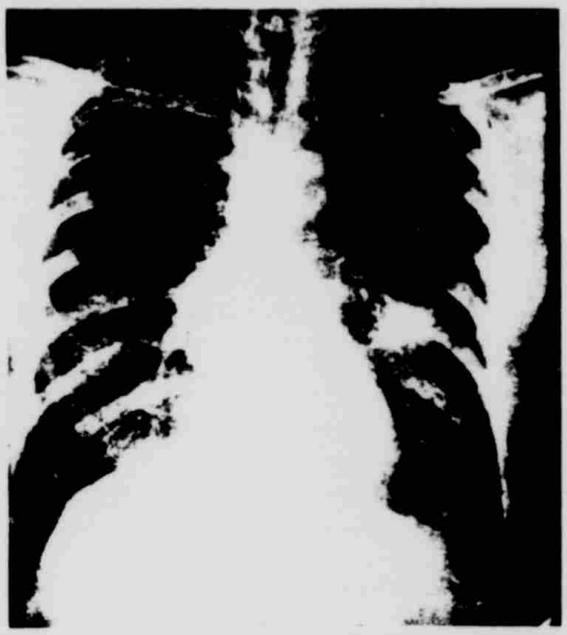


Figure 11–6 Chest radiograph of welder with massive shadow in left lung field. Fine reticulonodulation is present in lower lung fields.

shadow appears (Fig. 11–6).[73] It is felt that when conglomeration is seen in a welder, it can be assumed that he has been exposed to dusts other than iron, of which by far the most common is silica.

Radiographic Features

Siderosis, whatever its occupational origin, has similar appearances to and cannot be distinguished from simple silicosis.[62, 63, 67] Massive shadows are extremely rare.

Pulmonary Function

There seems little doubt that in its pure form siderosis does not lead to pulmonary impairment. Morgan and Kerr in their study of welders measured all aspects of pulmonary function with the exception of the diffusing capacity.[67] Despite the fact that the subjects studied by them had markedly abnormal chest films and despite the fact that the iron content of their lungs was grossly increased, neither the ventilatory capacity, res-

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piratory mechanics, nor the arterial blood gases were abnormal except in those subjects who had a mixed exposure. At a later date Stanescu and co-workers studied the pulmonary mechanics of a group of sixteen working welders with abnormal chest films.[74] They compared the welders to a group of thirteen unexposed healthy men, and showed that arc welders had a statistically significant reduction in the static and functional compliance of the lungs. However, measurement of elastic recoil at total lung capacity did not separate the welders from the controls. It is difficult to assess the significance of the results in this investigation, and ideally an additional control group of welders without radiographic abnormalities should have been included. Either way, it is difficult to equate slight changes in static compliance with respiratory symptoms, and the effect, if any, that such changes have on the development of respiratory disability can be assumed to be negligible.

Well controlled epidemiological studies of the respiratory status of welders are few. Hunnicutt and his colleagues studied the ventilatory capacity of one hundred welders and an equal number of controls.[75] Although obstructive airways disease was found in both groups, there was no significant difference between them when the effects of smoking were taken into account. Peters et al. studied sixty-one welders with a questionnaire, chest film, and more detailed tests of pulmonary function.[76] During the study, extensive air sampling was also carried out. These workers were unable to show that welders had a significant decrease in pulmonary function when compared to other shipyard workers. Nevertheless, there was some indication that shipyard workers as a whole had a lower ventilatory capacity than did the general population. Like Morgan and Kerr,[67] they concluded that nonsmoking welders do not suffer from a reduction in ventilatory capacity.

Prevention

Although iron in its pure form appears relatively harmless, some welders and oxyacetylene cutters are exposed to various dusts and fumes other than ferric oxide. In some instances these dusts can lead to fibrosis. Such exposures often include the oxides of nitrogen, ozone, and other air pollutants. Siderosis and metal fume fever are seen, and most commonly occur, in welders who work indoors in a poorly ventilated workroom. Both are uncommon when ventilation is adequate and when the men are working outside.

Silver Polishers' Lung

This differs somewhat from the pure siderosis seen in most welders. The jeweler's rouge that is used for polishing formerly consisted of iron oxide mixed with oil; however, with the widespread use of a buffing

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wheel, also known as a dolly, the powder is now dampened with water only. The dust generated during the polishing process consists of silver and iron oxide particles. As such the inhaled iron is picked up by the phagocytes, while the silver combines with the protein of the lung with the result that the elastic tissue is stained black.

STANNOSIS

Tin is an important metal because of its pliability and because of the fact that it readily forms alloys with other metals. After gold and copper, tin was the earliest metal used by man. According to Hoover and Hoover, the smelting of tin took place in the neolithic age, that is to say, about 5000 years ago.[77] Both the Phoenicians and Carthaginians traded with the inhabitants of Cornwall in order to obtain tin.

Deposits of tin are widely distributed throughout the world. Until the industrial revolution most of the world's tin came from Cornwall, Saxony, and Bohemia. Now most originates from Malaysia, Thailand, Bolivia, Nigeria, and to a lesser extent Zaire (Belgian Congo) and Australia. The most important ore is known as cassiterite (SnO_2); it occurs in veins that are often intimately related to granite and other rocks with a high silica content. Seventy per cent of the world's total production today comes from secondary alluvial deposits that result from the disintegration of primary deposits. In Bolivia tin is also extracted from various sulfide ores such as stannite (Cu_2FeSnS_2) and tealite ($PbZnSnS_2$).

Lode or underground mining for tin was formerly the main method of extracting the metal. The process involved removing a layer of rock with enough cassiterite in it to make the extraction profitable, a state of affairs that necessitated at least 1 per cent tin in the rock.[78] However, the concentration of tin in any lode almost never exceeds 10 per cent. A lode mine is usually started as a tunnel that is bored into the hillside and then often is redirected downward. Some Cornish tin mines went down to a depth of 1000 feet, but elsewhere depths of 3000 feet were not too uncommon. The cassiterite-containing rock has to be broken up, and this is mainly done by shot-firing. Compressed air drills are used to bore the holes for the insertion of the explosives. The surrounding strata frequently are composed of rock with a high free silica content and silicosis used to be common in tin miners. Ventilation and wet drilling have reduced the prevalence of the disease greatly. In Cornish tin mines, hookworm infection also used to be relatively common.

The method of extraction of tin is related to the type of deposit. Cassiterite is usually dredged from the sea or river bed. After it has been dug or excavated, it is washed and the mud and other superfluous materials are eliminated. In order to achieve this, primary and secondary washing operations are necessary, but even so the concentrate is usually only about 70 per cent pure.

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Figure 11–7 Chest radiograph of subject with stannosis. (Courtesy of Dr. C. Dundon.)

The inhalation of tin leads to a benign pneumoconiosis known as stannosis.[78-80] Most of the subjects who develop stannosis are involved in bagging of the concentrate or in smelting operations. During the latter process, hot gases containing minute particles of tin are given off from the molten metal as it leaves the furnace, and it is these that are responsible for the development of stannosis.

Stannosis is not associated with symptoms but there is a relatively distinctive radiographic appearance that resembles welders' siderosis (Fig. 11–7). The small opacities present in the radiograph appear extremely radiopaque. The macroscopic appearances of the lung have been described by Robertson and his colleagues.[79] Blackish or gray macules ranging between 2 and 5 mm. are present in the lungs (Fig. 11–8). These are relatively evenly distributed, and dust pigmentation of the interlobular septa is often evident. Microscopically the dust foci can be seen to be composed of aggregates of dust-laden macrophages which tend to surround the respiratory bronchioles. Occasionally dust-laden cells may be seen in the alveoli, in the interlobular septa, and in the perivascular lymphatics. Focal emphysema occurs but is not as prominent or as frequent as in coal workers' pneumoconiosis. Fibrosis is ab-

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Figure 11-8 Large lung section showing greyish deposits (macules) of tin. The macules range between 2 and 5 mm. in size.

sent, and complicated pneumoconiosis (progressive massive fibrosis) does not occur. There appears to be no evidence of significant pulmonary impairment in stannosis.[78, 79] Analysis of the lungs of subjects dying with, but not because of, stannosis have yielded between 30 and 40 per cent tin oxide.[79] There is a reasonably good relationship between the tin content and the radiographic category of subjects with stannosis. It must, however, be realized that very little tin needs to be retained in the lungs before radiographic abnormalities appear, and indeed it requires ten times as much coal to induce the same radiographic category. This phenomenon is a consequence of the fact that while tin has an atomic number of 50, carbon has an atomic number of 6. In conclusion, it appears that although the inhalation of tin produces a benign pneumoconiosis, generally known as stannosis, the condition is not associated with

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either morbidity or a decreased life expectancy, and in this context, one wonders whether it is correct to label the condition a pneumoconiosis.

THESAUROSIS

In 1958 Bergmann and colleagues described several subjects with a chronic pulmonary disease which they termed thesaurosis or storage disease.[81] The condition occurred in young women exposed to hair spray, and was attributed by them to the inhalation of polyvinylpyrrolidine (PVP), the major constituent of hair sprays. The first two patients described were asymptomatic young women with a history of heavy exposure to hair spray. Both had pulmonary infiltrates and hilar adenopathy. A granulomatous reaction was found in an excised scalene lymph node from one subject. In an attempt to develop an animal model for the condition, Bergmann and colleagues injected hair spray residue into the inguinal region of guinea pigs and produced a granulomatous reaction.

In 1962 Bergmann et al. reported twelve new cases, including three autopsies.[82] They added a more detailed clinical description, claiming that the condition is characterized radiographically by fluffy, hazy infiltrates and hilar adenopathy. They stated that when the use of hair spray was stopped, the disease resolved. Lymph node biopsy revealed findings which varied from reticuloendothelial hyperplasia to frank sarcoid granulomata. The microscopic lesions in the lung resembled those found in interstitial pneumonitis of the Hamman-Rich type; however, in subjects who had the condition for some time, the appearances were more suggestive of fibrosing alveolitis. Granulomata were sometimes seen in the lung. These workers made much of the presence of PAS-positive granules which they observed in the lung parenchyma, and at first implied that they were a specific finding in thesaurosis. However, since then the granules have been described in several other conditions. Following Bergmann and colleagues' description, there have been numerous case reports of one or two subjects with so-called thesaurosis.[83-85]

Unfortunately, good evidence that thesaurosis is an entity in its own right is sadly lacking. The name thesaurosis is presumably derived from the Greek "thesauros" which in English becomes "thesaurus" and which is best translated as a treasury or repository. Bergmann et al. regarded the condition as a "storage disease;" however, its relative infrequency in persons exposed to hair spray suggests strongly that it is a manifestation of hypersensitivity, if indeed it exists at all. In many reports of so-called thesaurosis, the clinical picture, x-ray findings, and even pathology were almost pathognomonic of sarcoid. Moreover, most subjects with sarcoidosis, in particular those with hilar adenopathy, improve spontaneously. The subjects described by Bergmann and his colleagues could equally well have had sarcoidosis,[81, 82] and the fact that

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the condition improved when the subjects stopped using the hair spray is likely to have been entirely fortuitous.

A failure to demonstrate PVP in the lungs of several of the subjects who have been reported as having this condition is further circumstantial evidence against the concept of thesaurosis. The fact that PVP has been shown to be retained in the lymph nodes is to be expected, since being inert, once it is deposited in the lungs the macrophages have to take it somewhere. Animal experiments have likewise failed to give any evidence in favor of the existence of thesaurosis.[86-88] The ultimate acceptance or rejection of thesaurosis must depend on well controlled epidemiological studies. The study conducted by McLaughlin and Bidstrup best fits this description.[89] These authors were unable to find a single subject with thesaurosis in a survey of 505 hairdresssers. A similar study carried out by Sharma and Williams in which the lung volumes and diffusing capacity of sixty-two exposed cosmetologists were compared to those of thirty-three controls likewise provided no evidence that thesaurosis exists.[90] Larson also failed to find any evidence of ventilatory impairment in users of hair spray.[91] In a survey of 227 beauty operators, Gowdy was unable to discover a single subject with thesaurosis.[85] He noted increased bronchovascular markings in eleven subjects, however, the significance, and indeed the very presence, of this nonspecific finding are open to doubt. In a series of circuitous arguments, Gowdy reviewed the evidence for the existence of thesaurosis, and argued that neither clinically, physiologically, pathologically, nor epidemiologically is there anything which differentiates thesaurosis from sarcoidosis. Then by means of a splendid piece of "a posteriori" logic, he concludes that thesaurosis could conceivably be an entity. Suffice it to say that in the absence of epidemiological proof, the existence of thesaurosis cannot as yet be accepted.

TITANIUM PNEUMOCONIOSIS

Titanium oxide is used as a white pigment in the manufacture of paint. The carbide of titanium finds extensive use with tungsten carbide in the manufacture of tools. There is some evidence that titanium oxide may produce radiographic abnormalities similar to those seen following the inhalation of iron and tin; however, there is no associated pulmonary impairment.[92]

TUNGSTEN CARBIDE PNEUMOCONIOSIS (HARD METAL DISEASE)

Hard metal is produced by the metallurgical blending of tungsten and carbon, with cobalt being used as a binder. Tungsten carbide is a

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metal that is extremely hard and resistant to heat, and is therefore used in the cutting of metals and in the manufacture of dental drills and bearings. Tools made of hard metal remain sharp at temperatures up to 3000° F.

Tungsten carbide is prepared by mixing extremely fine particles (0.5 to 15 microns) of tungsten and carbon. The majority of such particles are at the small end of the spectrum and range between 1 and 2 microns. The tungsten carbide is then milled with the addition of between 3 and 25 per cent cobalt. The tiny hard metal crystals are deposited on the cobalt. During this process, nickel, titanium, and other metals may be added according to the desired properties of the hard metal. When the tungsten carbide has been milled, paraffin is added to provide body prior to pressing of the metal into ingots. The carbide is then deparaffinized and sintered into hard metal. In each of these processes, fine dust is produced which contains both cobalt and tungsten particles. The manufacturing process is described in detail by Bech, Kipling, and Heather.[93]

History and Clinical Features of Hard Metal Disease

In 1940 Jobs and Ballhausen, while examining a group of twenty-seven German workers, found that eight of them had an abnormal chest radiograph.[94] A fine reticulonodulation was present. In 1959 Moschinski and colleagues examined 696 hard metal workers and found a high prevalence of bronchitis.[95] In a substantial percentage of the sample there also was radiographic evidence of pneumoconiosis. In the United States Fairhall et al. surveyed almost two thousand tungsten carbide workers.[96] Conjunctivitis, rhinitis, tracheitis, and bronchitis were frequently found. Pruritus and cobalt sensitivity were also common. Some subjects included in this sample had radiographic evidence of a pneumoconiosis. It thus appears that there are two types of respiratory disease seen in tungsten carbide workers: (1) an interstitial fibrotic process, and (2) an obstructive airways syndrome.

(1) Interstitial Fibrosis Due to Hard Metal. The most recent and detailed description of hard metal disease is that of Coates and Watson.[97] These workers described twelve subjects with diffuse interstitial lung disease of whom no fewer than eight died. The early symptoms of hard metal disease are cough and scanty mucoid sputum. Later the affected subject complains of shortness of breath which progressively worsens. Tachypnea is frequent but clubbing of the digits and basal crackles are late features of the condition. Pulmonary function measurements reveal reduced lung volumes, arterial desaturation, and a low diffusing capacity. The pattern is that of classical restrictive disease without significant airways obstruction. Death is usually a consequence of pulmonary hypertension and cor pulmonale.

Chest symptoms usually appear before the film becomes abnormal.

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Disease is seldom seen without at least ten years of exposure, but longer and shorter periods of exposure have been reported. Radiographically, the disease usually presents as a fine reticular-nodular pattern in the mid and lower zones, but the upper zones are occasionally predominantly affected. The heart outline is often blurred as in asbestosis, and a fine honeycombing may develop, as in other pulmonary fibroses.

Pathology. Although the lungs usually appear diffusely involved in the chest film, the fibrosis may be distributed in a patchy fashion. The interstitial tissue is infiltrated with histocytes and plasma cells and the alveolar septa are thickened by fibrous tissue. Often present is a granulomatous reaction very similar to that seen in berylliosis. Cystic air spaces lined by cuboidal epithelium are found later on in the disease. The alveoli contain what are assumed to be desquamated mononuclear cells, probably type II alveolar pneumocytes.

Coates and Watson carried out electron microscopy in several of their subjects.[98] They demonstrated excessive deposition of collagen and elastic tissue in the septa and the presence of multifaceted crystals thought to be tungsten carbide. The alveolar lining cells were markedly affected.

(2) Obstructed Airways Syndrome. This appears to be an allergic response and is characterized by wheezing, cough, and shortness of breath while at work. The symptoms often improve when the subject is home. In this it resembles, to some extent, byssinosis. There is no evidence that this type of disease progresses to interstitial fibrosis. Bech and his colleagues have shown that in a small proportion of workers who have the obstructive syndrome, the respiratory mechanics deteriorate over the day.[93] Most subjects in whom a severe obstructive response develops leave their job. Coates and colleagues recently described this syndrome in more detail. They described nine subjects with the typical syndrome.[99] Itching was present in three of them. The symptoms cleared up after work and at weekends and recurred when they returned. The syndrome did not develop until the subjects had had between six and eighteen months' exposure and sensitization had occurred. They showed that cobalt was toxic to the affected subjects' leukocytes but that tungsten had no effect. Challenge studies with cobalt, but not tungsten, produced an airways response.

Much experimental work suggests that cobalt is the responsible agent for both the interstitial and obstructive syndromes. Harding showed powdered cobalt to be toxic, whether given intratracheally or by inhalation. He also demonstrated that the metal is much more soluble in plasma than in saline.[100] However, tungsten carbide in the absence of cobalt is inert. Delahant produced chronic bronchiolitis and metaplastic changes in the alveoli with pulverized cobalt but not with tungsten carbide, titanium, or tantalum.[101] No treatment is known for the interstitial

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disease but steroids may be worth trying. The obstructive syndrome is best avoided either by limiting the man's exposure to dust or, failing this, by the wearing of a mask.

REFERENCES

1. Shaver, C. G., and Riddell, A. R., Lung changes associated with the manufacture of alumina abrasives, J. Ind. Hyg. 29, 145, 1947.
2. Goralewski, G., Die Aluminiumlunge (Arbeithsmedizin No. 26), Leipzig, 1950.
3. Barth, G., Frik, W., and Scheidemandel, H., Die Aluminiumlunge, Verlaufsbeobachtungen and neuerkrankungen in der nachkriegszeit, Deutsch. med. Wschr., *81*, 1115, 1956.
4. Hunter, D., Milton, R., Perry, K. M. A., and Thompson, D. R., Effect of aluminium and alumina on the lung in grinders of duralumin aeroplane propellers, Brit. J. Ind. Med. *1*, 159, 1944.
5. Mitchell, J., Pulmonary fibrosis in an aluminium worker, Brit. J. Ind. Med. *16*, 123, 1959.
6. Mitchell, J., Manning, G. B., Molyneux, M., and Lane, R. E., Pulmonary fibrosis in workers exposed to finely powdered aluminium, Brit. J. Ind. Med. *18*, 10, 1961.
7. Jordan, J. W., Pulmonary fibrosis in a worker using an aluminium powder, Brit. J. Ind. Med. *18*, 21, 1961.
8. McLaughlin, A. I. G., Kazantzis, G., King, E., Teare, D., Porter, R. J., and Owen, R., Pulmonary fibrosis and encephalopathy associated with the inhalation of aluminium dust, Brit. J. Ind. Med. *19*, 253, 1962.
9. Corrin, B., Aluminium pneumoconiosis. I. In vitro comparison of stamped aluminium powders containing different lubricating agents and a granular aluminium powder, Brit. J. Ind. Med. *20*, 264, 1963.
10. Corrin, B., Aluminium pneumoconiosis. II. Effect on the rat lung of intratracheal injections of stamped aluminium powders containing different lubricating agents and of a granular aluminium powder, Brit. J. Ind. Med. *20*, 268, 1963.
11. Cooper, D. A., Pendergrass, E. P., Vorwald, A. J., Mayock, R. L., and Brieger, H., Pneumoconiosis in workers in an antimony industry, Amer. J. Roent. *103*, 495, 1968.
12. McCallum, R. I., Work on an occupational service in environmental control, Ann. Occup. Hyg. *6*, 60, 1963.
13. Klucik, I., Juck, A., and Gruberova, J., Respiratory and pulmonary lesions caused by antimony trioxide dust, Prac. lek., *14*, 363, 1962.
14. McLaughlin, A. I. G., Iron and Other Radio-opaque Dusts: Industrial Pulmonary Diseases, Boston, Little, Brown & Company, 1960, pp. 146–167.
15. Pimentel, J. C., A granulomatous lung disease produced by Bakelite, Amer. Rev. Resp. Dis. *108*, 1303, 1973.
16. Arrigoni, A., La pneumoconiosis da bario, Clin. Med. Ital. *64*, 299, 1933.
17. Arrigoni, A., La pneumoconiosis da bario, Med. Lavoro *24*, 461, 1933.
18. Pendergrass, E., and Greening, R., Baritosis, report of case, A.M.A. Arch. Ind. Hyg. *7*, 44, 1953.
19. Doig, A. T., Baritosis, in XV International Congress on Occupational Health, Wiener Medizenische Akademie, Verlag Wien, 1966.
20. Van Ordstrand, H. S., Hughes, R., De Nardi, J. M., and Carmody, M. G., Beryllium poisoning, J.A.M.A. *129*, 1084, 1945.
21. Van Ordstrand, H. S., Acute beryllium poisoning, in Vorwald, A. J., ed., Sixth Saranac Symposium (1947), Pneumoconiosis: Beryllium, Bauxite Fumes, Compensation, New York, P. B. Hoeber, 1950, p. 65.
22. De Nardi, J. M., Van Ordstrand, H. S., and Carmody, M. G., Acute dermatitis and pneumonitis in beryllium workers: Review of 406 cases in 8 year period with follow-up on recoveries, Ohio State Med. J. *45*, 467, 1949.

Published by AsbestosClaims.Law
asbestosclaims.law/library/25368/32

23. Hardy, H. L., and Tabershaw, I. R., Delayed chemical pneumonitis occurring in workers exposed to beryllium compounds, J. Ind. Hyg. Toxicol. *28*, 197, 1946.
24. Chesner, C., Chronic pulmonary granulomatosis in residents of a community near a beryllium plant: Three autopsied cases, Ann. Intern. Med. *32*, 1028, 1950.
25. Eisenbud, M., Wanta, R. C., Dustan, C., Steadman, L. T., Harris, W. B., and Wolf, B. S., Non-occupational beryllosis, J. Ind. Hyg. Toxicol., *31*, 282, 1949.
26. Hardy, H. L., and Stoeckle, J. D., Beryllium disease, J. Chron. Dis. *9*, 152, 1959.
27. Hardy, H. L., Beryllium disease: A continuing diagnostic problem, Amer. J. Med. Sci. *242*, 150, 1961.
28. Van Ordstrand, H. S., Diagnosis of beryllium disease, A.M.A. Arch. Ind. Health *19*, 157, 1959.
29. Resnick, H., Roche, M., and Morgan, W. K. C., Immunoglobulin concentrations in berylliosis, Amer. Rev. Resp. Dis. *101*, 504, 1970.
30. Wright, G. W., Chronic pulmonary granulomatosis of beryllium workers, Trans. Amer. Clin. Climatol. Assoc. *61*, 161, 1949.
31. Gaensler, E. A., Verstraeten, J. M., Weil, W. B., Cugell, D. W., Marks, A., Cadigan, J. B., Jones, R. H., and Ellicott, M. F., Respiratory pathophysiology in chronic beryllium disease, A.M.A. Arch. Ind. Health *19*, 132, 1959.
32. Ferris, B. G., Affeldt, J. E., Kriete, H. A., and Whittenberger, J. L., Pulmonary function in patients with pulmonary disease treated with ACTH, A.M.A. Arch. Ind. Hyg. *3*, 603, 1951.
[illegible]urtis, G. H., Cutaneous hypersensitivity due to beryllium, A.M.A. Arch. Derm. Syph. *64*, 470, 1951.
[illegible]ldon, I. B., Berylliosis, a case report, Brit. Med. J. *1*, 1448, 1955.
[illegible]sman, B. H., The diagnosis of beryllium disease with special reference to the patch test, A.M.A. Arch. Ind. Health, *19*, 154, 1959.
James, D. G., Dermatological aspects of sarcoidosis, Quart. J. Med. *28*, 109, 1959.
37. Dutra, F. R., Cholak, J., and Hubbard, D. M., The value of beryllium determination in the diagnosis of berylliosis, Amer. J. Clin. Path. *19*, 229, 1949.
38. Williams, W. J., A histological study of the lungs in 52 cases of chronic beryllium disease, Brit. J. Ind. Med. *15*, 84, 1958.
39. Marx, J. J., Jr., and Burrell, R., Delayed hypersensitivity to beryllium compounds, J. Immunol. *111*, 590, 1973.
[illegible]dhar, S. D., Barna, B., and Van Ordstrand, H. S., A study of the immunologic aspects of chronic berylliosis, Chest *63*, 309, 1973.
Schute, H. F., Beryllium, the criteria document, J. Occup. Med. *15*, 663, 1973.
42. Nappee, J., Bobrie, J., and Lambard, D., Pneumoconiose au cérium, Arch. Mal. Prof. *33*, 13, 1972.
43. Gaensler, E. A., Cadigan, J. B., Sasahara, A. A., Fox, E. O., and MacMahon, H. E., Graphite pneumoconiosis of electrotypers, Amer. J. Med. *41*, 864, 1966.
[illegible]ltkemper, I., and Teleky, L., Studien uber Staublunge: die Staublunge in einzelnen besonderen Betrieben und bei besonderen Arbeiten, Arch. Gewerbepath. *3*, 600, 1932.
45. Gartner, K., and Brauss, F. W., Russ pneumoconiosis, Med. Welt *20*, 252, 1951.
46. Gloyne, S. R., Marshall, G., and Hoyle, C., Pneumoconiosis due to graphite dust, Thorax *4*, 31, 1949.
47. Meiklejohn, A., in reports, 12th International Congress on Occupational Health, Vol. 3, Helsinki, Helsingfors Publications, 1957, p. 335.
48. Koelsch, F., Zum Problem der Graphitpneumoconiose, Zbl. Arbeitsmed. *8*, 1, 1958.
49. Watson, A. J., Black, J., Doig, A. T., and Nagelschmidt, G., Pneumoconiosis in carbon electrode makers, Brit. J. Ind. Med. *16*, 274, 1959.
50. Miller, A. A., and Ramsden, F., Carbon pneumoconiosis, Brit. J. Ind. Med., *18*, 103, 1961.
51. Lister, W. B., Carbon pneumoconiosis in a synthetic graphite worker, Brit. J. Ind. Med. *18*, 114, 1961.
52. Parmeggiani, L., Graphite pneumoconiosis, Brit. J. Ind. Med. *7*, 42, 1950.
53. Stewart, M. J., and Faulds, J. S., The pulmonary fibrosis of haematite miners, J. Path. Bact., *39*, 233, 1934.
54. Boyd, J. T., Doll, R., Faulds, J. S., and Leiper, J. Cancer of the lung in iron-ore (haematite) miners, Brit. J. Ind. Med. *27*, 97, 1970.

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asbestosclaims.law/library/25368/33

55. Roche, A. D., Picard, D., and Vernhes, A., Silicosis of ochre workers (a clinical and anatomo-pathologic study), Amer. Rev. Tuberc. *77*, 839, 1958.
56. McLaughlin, A. I. G., and Harding, H. E., Pneumoconiosis and other causes of death in iron and steel foundry workers, Arch. Ind. Health, *14*, 350, 1956.
57. McLaughlin, A. I. G., Pneumoconiosis in foundry workers, Brit. J. Tuberc. *51*, 297, 1957.
58. Harding, H. E., and Massie, A. P., Pneumoconiosis in boiler scalers, Brit. J. Ind. Med., *8*, 256, 1951.
59. Jones, J. G., and Warner, C. G., Chronic exposure to iron oxide, chromium oxide and nickel oxide fumes of metal dressers in a steelworks, Brit. J. Ind. Med., *29*, 169, 1972.
60. Evans, D. J., and Posner, E., Pneumoconiosis in laundry workers, Environ. Res. *4*, 121, 1971.
61. Zenker, F. A., Ueber Staublinhalationskrankheiten der Lung, Deutsch. Arch. Klin. Med. *2*, 116, 1866.
62. Doig, A. T., and McLaughlin, A. G., X-ray appearances of the lungs of arc-welders, Lancet *1*, 771, 1936.
63. Harding, H. E., McLaughlin, A. I. G., and Doig, A. T., Clinical radiographic and pathological studies of the lungs of electric arc and oxyacetylene welders, Lancet *II*, 394, 1958.
64. Barrie, H. F., and Harding, H. E., Argyro-siderosis of the lungs in silver finishers, Brit. J. Ind. Med. *4*, 225, 1947.
65. Colleen, M. F., A study of pneumonia in shipyard workers with special reference to welders, J. Ind. Hyg. 29, 113, 1947.
66. Doig, A. T., and Duguid, L. N., The health of welders, Ministry of Labour and National Service, London, H.M. Stationery Office, 1951, p. 68.
67. Morgan, W. K. C., and Kerr, H. D., Pathologic and physiologic studies of welder's siderosis, Ann. Intern. Med. 58, 293, 1963.
68. Charr, R., (a) Respiratory disorders among welders, J.A.M.A. *152*, 1520, 1953; (b) Respiratory disorders among welders, Amer. Rev. Tuberc. *71*, 877, 1955; (c) Pulmonary changes in welders, Ann. Intern. Med. *44*, 806, 1956.
69. Mann, B. T., and Lecutier, E. R., Arc welders' lung, Brit. Med. J. *II*, 921, 1957.
70. Friede, E., and Rachow, D. O., Symptomatic pulmonary disease in arc welders, Ann. Intern. Med. *54*, 121, 1961.
71. Schiotz, E. H., Welding regarded from the medical point of view, Acta Med. Scand. *121*, 537, 1945.
72. Harding, H. E., Grout, J. L. A., and Lloyd Davies, T. H., The experimental production of x-ray shadows in the lungs by inhalation of industrial dusts. I. Iron oxide, Brit. J. Ind. Med. *4*, 223, 1947.
73. Morgan, W. K. C., Arc welders' lung complicated by conglomeration, Amer. Rev. Resp. Dis. *85*, 570, 1962.
74. Stanescu, D. C., Pilat, L., Gavrilescu, N., Teculescu, D. B., and Cristescu, I., Aspects of pulmonary mechanics in arc welders' siderosis, Brit. J. Ind. Med. *24*, 143, 1967.
75. Hunnicutt, T. N., Cracovaner, D. J., Myles, J. T., Spirometric measurements in welders, Arch. Environ. Health, *8*, 661, 1964.
76. Peters, J. M., Murphy, R. L. H., Ferris, B. G., Burgess, W. A., Ranadive, M. V., and Pendergrass, H. P., Pulmonary function in shipyard welders, Arch. Environ. Health, *26*, 28, 1973.
77. Hoover, H. C., and Hoover, H. L., Footnotes, in Agricola, G., De re metallica, 1556, London, 1912, pp. 283, 354.
78. Robertson, A. J., The romance of tin, Lancet, *1*, 1229, 1289, 1964.
79. Robertson, A. J., Rivers, D., Nagelschmidt, G., and Duncumb, P., Stannosis, Lancet, *1*, 1089, 1961.
80. Pendergrass, E. P., and Pryde, A. W., Benign pneumoconiosis due to tin oxide: A case report with experimental investigation of the radiographic density of the tin oxide dust, J. Ind. Hyg. *30*, 119, 1948.
81. Bergmann, M., Flance, I. J., and Blumenthal, H. T., Thesaurosis following inhalation of hair spray; A clinical and experimental study, New Eng. J. Med. 258:471, 1958.
82. Bergmann, M., Flance, I. J., Cruz, P. T., et al., Thesaurosis due to inhalation of hair

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spray. Report of 12 new cases, including three autopsies, New Eng. J. Med. *266*, 750, 1962.
83. Edelston, B. G., Thesaurosis following inhalation of hair spray, Lancet *II*, 112, 1959.
84. Nevins, M. A., Stechel, G. H., Fishman, S. I., et al., Pulmonary granulomatoses: Two cases associated with inhalation of cosmetic aerosols, J.A.M.A. *193*, 266, 1965.
85. Gowdy, J. M., Pulmonary infiltration due to aerosol thesaurosis, Arch. Environ. Health *25*, 101, 1972.
86. Draize, H. J., Nelson, A. A., Newburger, S. H., et al., Inhalation toxicity studies of six types of aerosol hair sprays, Proc. Sci. Sec. Toilet Goods Assoc. *31*, 28, 1959.
87. Calandra, J., and Kay, J. A., The effects of aerosol hair sprays on experimental animals, Proc. Sci. Sec. Toilet Goods Assoc. *30*, 41, 1958.
88. Giovacchini, R. P., Becker, G. H., Brunner, M. J., and Dunlap, F. E., Pulmonary disease and hair spray polymers, J.A.M.A. *193*, 298, 1965.
89. McLaughlin, A. I. G., and Bidstrup, P. L., The effects of hair lacquer sprays on the lungs, Fed. Cosmet. Toxicol. *1*, 171, 1963.
90. Sharma, O. P., and Williams, M. H., Thesaurosis, Arch. Environ. Health *13*, 616, 1966.
91. Larson, R. K., A study of mid-expiratory flow rate in users of hair spray, Amer. Rev. Resp. Dis. *91*, 786, 1964.
92. Schmitz-Moorman, P., Horlein, H., and Hanefeld, F., Lungenveranderungen bei Titandioxyd staub Exposition, Beitr. Silikose forschung. *80*, 1, 1964.
93. Bech, A. O., Kipling, M. D., and Heather, J. C., Hard metal disease, Brit. J. Ind. Med. *19*, 239, 1962.
94. Jobs, H., and Ballhausen, C., quoted by Bech et al., Vertrauensarzt *8*, 142, 1940.
95. Moschinski, G., Jurisch, A., and Reinl, W., Die Lungenveranderungen bei Sinterhartmetallarbeitern, Arch. Gewerbepath. *16*, 697, 1959.
96. Fairhall, L. T., Castberg, H. T., Carrozzo, N. J., and Brinton, H. P., Industrial hygiene aspects of the cemented tungsten carbide industry, Occup. Med. *4*, 371, 1947.
97. Coates, E. O., Jr., and Watson, J. H. L., Diffuse interstitial lung disease in tungsten carbide workers, Ann. Intern. Med. *75*, 709, 1971.
98. Coates, E. O., Jr., and Watson, J. H. L., Pathology of the lung in tungsten carbide workers using light and electron microscopy, J. Occup. Med. *15*, 280, 1973.
99. Coates, E. O., Jr., Sawyer, H. J., Rebuck, J. W., Kvale, P. A., and Sweet, L. W., Hypersensitivity bronchitis in tungsten carbide workers, Chest *64*, 390, 1973.
100. Harding, H. E., Notes on the toxicology of cobalt metal, Brit. J. Ind. Med. *7*, 76, 1950.
101. Delahant, A. B., An experimental study of the effects of rare metals on animal lungs, A. M. A. Arch. Ind. Health *12*, 116, 1955.

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