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Abstract
This overview describes the main categories of specific occupational disorders and it covers also how work exposures are potential determinants of common respiratory conditions. Acute inhalation injuries may present as inhalation fever or as acute tracheobronchitis and pneumonitis. Occupational asthma is the most frequent work-related respiratory disease. It may be caused by allergic sensitization to macromolecules of biologic origin or to chemicals of low molecular weight, as well as by (heavy) exposure to workplace irritants. The pneumoconioses are caused by the accumulation of dust particles or fibres in the lungs. They include silicosis, coal workers’ pneumoconioses, asbestosis and other less common pneumoconioses. Chronic beryllium disease is caused by a cell-mediated sensitization to beryllium and resembles sarcoidosis. Hard-metal lung disease is caused by sensitivity to cobalt and resembles hypersensitivity pneumonitis. Extrinsic allergic alveolitis or hypersensitivity pneumonitis is generally caused by sensitization to aerosolized biological antigens. Several types of infections may be related more or less specifically to work. Chronic obstructive lung disease is mainly caused by cigarette smoking, but exposure to dusts and gases contribute to its incidence. Similarly, broncho-pulmonary cancer is not only caused by smoking, but also by occupational agents, most notably asbestos. Asbestos is also a cause of nonmalignant and malignant pleural disease.

Introduction
In industrially developed countries the frequency and severity of the traditional occupational diseases have decreased in the past decades, thanks to improvements in work legislation and practices. However, working conditions are still far from being acceptable, let alone healthy, in all areas of the world. In many poorer countries, considerable numbers of workers are exposed to serious hazards associated with underground mining, various types of industry (metal, textile, wood, food, electronics, etc.), construction, and agriculture. In industrially advanced countries, occupational lung diseases still occur as a consequence of working conditions of the past, but they also continue to occur, because occupational risks are still present in many jobs and novel risks emerge with the advent of new technologies.

In general, it is difficult, if not impossible, to quantify exactly the contribution of occupation to the burden of respiratory disease. Exact figures of the incidence and prevalence of occupational lung disorders are often not available, even in countries where government agencies exist for reporting and compensating occupational diseases. This is due, in varying proportions, to legal and administrative restrictions in the eligibility for compensation, to a lack of obligation or incentive to notify occupational diseases, and to insufficient awareness, by physicians, of the possible occupational etiology of diseases in general. Thus, underreporting of occupational diseases is most likely to occur for pensioners, who are no longer at work, but whose condition may well be due to their previous job. However, even in working people, diagnoses of occupational disease, such as occupational asthma, are often missed for a variety of reasons. In various countries, schemes have been created for the voluntary reporting of occupational respiratory diseases by pneumologists and/or occupational physicians, for example, the Surveillance of Work Related and Occupational Respiratory Disease (SWORD) system in the UK or the Sentinel Event Notification System for Occupational Risks (SENSOR) Program, initiated by the National Institute for Occupational Safety and Health (NIOSH) in the US.

Another, more generic reason for the underreporting of occupational lung disorders is that it is not always so easy to define occupational respiratory disease. Indeed, occupational respiratory diseases are not restricted to a limited range of highly specific occupational diseases, such as silicosis or asbestosis. Most common respiratory diseases, such as bronchial asthma, chronic obstructive pulmonary disease
(COPD), and bronchopulmonary cancer, are caused by a combination of endogenous and exogenous factors, including occupational exposures. Thus, even though an occupational etiology is often difficult to substantiate and document in individual patients, the attributable fraction of occupational factors in mortality and morbidity from respiratory diseases is far from being negligible.

This overview describes briefly the main categories of specific occupational respiratory disorders and it covers also briefly how work exposures are potential determinants of common respiratory conditions.

**Acute Inhalation Injuries**

**Inhalation Fever**

Inhalation fever is a clinical term used to describe influenza-like reactions that occur following a single exposure to high levels of:

- metal fumes (mainly zinc), causing metal fume fever;
- organic dusts (grain, cotton, etc.) and other bioaerosols contaminated with microorganisms and endotoxins and/or mycotoxins, causing the organic dust toxic syndrome (ODTS); and
- fumes produced by heating plastics (mainly fluorine-containing polymers), causing polymer fume fever.

These inhalation fevers are the clinical expressions of an intense nonallergic pulmonary inflammation, consisting mainly of neutrophils. These reactions are usually self-limited and not associated with much structural damage to the respiratory tract.

**Toxic Acute Tracheobronchitis and Pneumonitis**

Severe injury to the respiratory tract may result from the inhalation of irritant or toxic gases, vapors, or complex aerosols released through explosions, fires, leaks, or spills from industrial installations, transport accidents, and military or terrorist operations. Depending on the nature of the chemical and the intensity of the exposure, there will be rhinitis, pharyngitis, laryngitis, tracheobronchitis, bronchiolitis, and/or pneumonitis. Chemical pneumonitis is generally associated with noncardiogenic pulmonary edema, and may evolve to acute respiratory distress syndrome (ARDS). Organizing pneumonia with obliterating bronchitis may also be a feature of chemical injury to the terminal airspaces.

In survivors of acute inhalation injury, there may be persisting structural lesions or functional sequelae, such as the reactive airways dysfunction syndrome (RADS).

**Occupational Asthma**

In modern societies, occupational asthma is now considered the most frequent work-related respiratory disease. Occupational asthma is asthma that is causally related to an exposure at work. In addition to asthma that is caused – more or less clearly – by work, many asthmatics also experience a worsening of their asthma by their working circumstances. The latter is called ‘work-aggravated asthma’. The contribution of occupational factors to the causation and the manifestations of bronchial asthma has been recently estimated to amount to 15% of adult asthmatics. Excess risks of asthma are found for farmers, painters, plastic workers, cleaners, spray painters, and agricultural workers.

Depending on its pathogenesis, occupational asthma may be categorized into occupational asthma caused by immunologic (allergic) sensitization to a (specific) agent and asthma caused by other mechanisms.

**Occupational Asthma Caused by Allergic Sensitization**

A large number of workplace agents have been shown to be capable of causing sensitization and occupational asthma. These occupational ‘asthmogens’ include:

- macromolecules of biological origin, that is, (glyco)proteins derived from plants (flour, latex, etc.), animals (farm animals, laboratory animals, seafood, etc.), or microorganisms (enzymes in detergents, baking additives, animal feed, etc.);
- low-molecular-weight chemicals of natural origin (e.g., wood-derived chemicals);
- low-molecular-weight synthetic chemicals (diisocyanates and other reactive chemicals, pharmaceutical agents, reactive dyes, etc.); and
- metallic agents (complex platinum salts, hexavalent chromium, cobalt, etc.).

The mechanisms of sensitization involve IgE antibodies (for macromolecular antigens) or other less well-characterized immunological mechanisms (for chemicals).

**Occupational Asthma without Evidence of Specific Sensitization**

Irritant-induced occupational asthma may be caused either by a single acute inhalation accident (RADS), or through repeated or chronic exposure to excessive
levels of irritants. The latter is still somewhat controversial.

‘Asthma-like’ disorders without evidence of sensitization are also found in workers exposed to (endotoxin-contaminated) vegetable dusts (e.g., byssinosis in cotton workers, asthma-like syndrome in grain handlers and in swine confinement workers). These may form the basis for the high prevalence of COPD in agricultural workers.

Interstitial Lung Disease

Pneumoconioses

Pneumoconioses are diseases of the lung parenchyma caused by the accumulation of dust particles or fibers in the lungs. Although individual susceptibility plays some role, pneumoconiosis is considered to be caused essentially by the progressive accumulation of toxic particles beyond the lung’s normal clearance mechanisms. This leads to inflammation (characterized initially by increased numbers of alveolar macrophages) and various degrees and types of fibrosis, depending on the agent.

Silicosis Silicosis has become relatively uncommon in industrialized countries, thanks to dust controls in the workplace. Hazardous exposures to silica (SiO₂) may occur in mining, tunnel drilling or stone quarrying, in processing stone or sand, in building and demolition, in foundries, in pottery or ceramic manufacture, in the abrasive use of sand (sandblasting), in the manipulation of calcined diatomaceous earth, and other sometimes unexpected settings. Free crystalline silica (in practice, mainly quartz and cristobalite) is highly fibrogenic and leads to the formation of silicotic noduli. These lead initially to ‘simple silicosis’, characterized radiologically by small discrete opacities, and through coalescence they give rise to larger nodular opacities, characteristic of ‘progressive massive fibrosis’ (PMF). Silicosis is also associated with other conditions, such as COPD, tuberculosis, bronchopulmonary cancer, and collagen disease, including systemic sclerosis.

Coal workers’ pneumoconiosis The pathology of coal workers’ pneumoconiosis (CWP) differs from that of silicosis, but both conditions share many clinical features, including the potential for evolution towards PMF. Hence, and because coal miners are also exposed to varying amounts of silica, CWP is sometimes considered as a mixed pneumoconiosis, labeled anthracosilicosis.

Asbestosis Asbestosis (i.e., fibrosis of the lung parenchyma caused by asbestos) is found in patients who were heavily exposed to asbestos fibers (mainly chrysotile, and the serpentines crocidolite, amosite, and tremolite), for example, during the manufacture of asbestos–cement products, friction materials or fireproof textiles, or when using asbestos for heat insulation or fire protection purposes in construction, heating systems, power stations, furnaces, shipyards and railroads, etc. The incidence of asbestosis will continue to decrease in those countries where the use of asbestos has been forbidden. Nevertheless, a risk of asbestosis will remain for those engaged in asbestos removal and waste handling, as well as in developing countries where the use of asbestos is still allowed and poorly regulated. The pathology of asbestosis is very similar to that of idiopathic pulmonary fibrosis, from which it must be distinguished by the presence of asbestos bodies and/or associated asbestos pleural lesions.

Less common pneumoconioses Less common pneumoconioses include those caused by nonfibrous silicates (such as talc, kaolin, or mica) or other minerals. Some compounds cause so-called benign pneumoconioses (e.g., siderosis, caused by iron dust), a term implying the lack of serious fibrosis and functional impairment.

Some synthetic agents have also been associated with interstitial lung disease. Thus, exposure to polyvinyl chloride (PVC) dust has been shown to cause pneumoconiosis, and heavy exposure to synthetic microfibers (mainly nylon, but also polypropylene and polyethylene) can cause interstitial lung disease (‘flock worker’s lung’). Heavy exposure to aerosolized paints caused the Ardystil syndrome, a severe form of organizing pneumonia, in textile workers in Spain and in Algeria.

Chronic Beryllium Disease and Hard-Metal/Cobalt Lung Disease

These diseases are not included among the mineral pneumoconioses here, because their occurrence does not appear to be based as much on dust accumulation, as on individual susceptibility.

Chronic beryllium disease Chronic beryllium disease (CBD) or berylliosis is caused by sensitization to beryllium (Be), a light metal that is increasingly used in modern technology. CBD is a granulomatous lung disease and is clinically and pathologically similar to sarcoidosis. CBD is caused by a cell-mediated sensitization to Be, which can be demonstrated by proliferation of lymphocytes from peripheral blood or
bronchoalveolar lavage upon incubation with Be salts. The HLA-DPβ1 Glu69 allele confers a strong genetic susceptibility to develop CBD.

Other agents (e.g., talc, zirconium) have been associated with granulomatous lung disease, masquerading as sarcoidosis.

**Hard-metal lung disease** Hard-metal lung disease is a rare disease caused, in susceptible individuals, by exposure to cobalt (Co), as a component of hard metal (a composite based on tungsten carbide) or diamond–cobalt. Clinically the disease resembles hypersensitivity pneumonitis, although little evidence exists for an immune reaction against Co. In its most typical presentation, its pathology is characterized by giant cell interstitial pneumonia (GIP). The pathogenesis of hard-metal lung disease is not clear, but it may be related to the generation of oxidant species from the oxidation of Co.

**Extrinsic Allergic Alveolitis/Hypersensitivity Pneumonitis**

Occupational causes of extrinsic allergic alveolitis or hypersensitivity pneumonitis are quite diverse. The more common etiologies consist of dusts originating from microorganisms (farmer's lung, humidifier's lung) or from birds (pigeon breeder's lung, bird fancier's lung). However, all environments where there is inhalation of bio-aerosols should be considered as carrying a risk of extrinsic allergic alveolitis. These include mushroom farms, composting installations, wood processing, vegetable storage, machining shops (through the use of machining fluids), etc. Some chemicals, most notably isocyanates, may also cause the condition.

Occupational extrinsic allergic alveolitis has been studied most in farmers, in whom the disease is caused by sensitization to (thermophilic) microorganisms that grow in hay or other organic substrates. The frequency of farmer's lung exhibits a considerable geographic variation, depending on climatic factors and farming practices, and the causative antigens also differ between regions. It is most frequent in the cold humid climates of northern Europe and America or in mountainous areas, such as the Doubs in France.

**Occupational Infections**

Most respiratory infections are community-acquired, but sometimes they may be related to specific occupations. Common viral or, more rarely, bacterial infections may affect those working in crowded environments, schools, hospitals, and other communities. Immune-compromised subjects are at increased risk of acquiring invasive fungal infections in some work environments.

Tuberculosis is a well-recognized risk in health workers, but other categories of workers may be at risk, such as prison guards or social workers. Emerging infections pose a particular threat to hospital workers and their families, as shown by the recent outbreak of severe acute respiratory syndrome (SARS).

Workers involved in maintaining (hot) water pipes, reservoirs, pumps, or fountains may be at risk of contracting Legionella pneumonia. Working in wild environments may lead to infections such as histoplasmosis, tularemia, or hantavirus pneumonia. Other zoonoses, such as anthrax, Q fever, ornithosis, avian influenza, affect workers in jobs involving direct or indirect contact with farm animals or birds. Moreover, dissemination of anthrax and other microorganisms by terrorists is a definite threat for various categories of workers, such as postal workers, maintenance workers, law enforcement personnel, and health workers.

It is not established to what extent microorganisms and biological contaminants are responsible, together with indoor climate factors and volatile organic compounds, as well as psychosocial factors, for outbreaks of the ‘sick-building syndrome’. This syndrome refers to the occurrence, in a large proportion of the workforce, of non-specific work-related respiratory and other complaints among occupants of some buildings, particularly air-conditioned office buildings.

**Chronic Obstructive Pulmonary Disease**

Although the dominant cause of COPD is cigarette smoking, there is little doubt that occupational exposures to mineral dusts, organic dusts, and irritant gases or vapors contribute to the incidence and the severity of chronic airways disease, including COPD. The quantitative contribution of occupational factors to the burden of COPD morbidity or mortality has been estimated at 15%.

The most common respiratory manifestation of exposure to dusts or fumes consists of the presence of chronic bronchitis, that is, ‘industrial bronchitis’, which may or may not be associated with airflow limitation. Several longitudinal studies have shown that exposure to mine dust is associated with a loss of ventilatory function, even in the absence of pneumoconiosis. Other occupations with exposure to mineral dusts (such as building workers) or fumes (such as welders) are probably also at risk of occupationally induced COPD. Exposure to agricultural
dusts (such as grain dust or vegetable fibers) is also a significant cause of chronic airway disease.

** Bronchopulmonary Cancer **

As is the case for COPD, the most important exogenous factor in causing bronchopulmonary cancer is cigarette smoking. However, numerous epidemiological studies have investigated the role of occupational exposures in causing lung cancer, and despite the many difficulties of such studies, many occupational agents (or jobs) have been identified as definite or probable causes of lung cancer. Thus, asbestos fibers, some chromium(VI) compounds, arsenic, radon gas and its decay products (radon daughters), bis(chloromethyl)ether (BCME), and crystalline silica (occupational exposure) are well-established human lung carcinogens (belonging to category 1 of the International Agency for Research on Cancer (IARC)). Depending on the agent, as well as on methodological aspects, additive or multiplicative modes of interaction have been shown to operate with cigarette smoking. Established carcinogenic processes for the lung include coke production and coal gasification (possibly related to polycyclic aromatic hydrocarbons), iron and steel founding, paint manufacture and painting. Occupational exposure to diesel exhaust and environmental tobacco smoke are also probable causes of lung cancer, although the magnitude of the risk is smaller than that found for the established carcinogenic agents.

The contribution of occupation to the causation of lung cancer has been shown to be considerably larger than for most other common cancers. The most frequently quoted estimate is 15% for males and 5% for females, and occupational asbestos exposure is considered the most influential factor.

** Pleural Disease **

Occupational pleural disorders concern almost exclusively those who have had exposure to asbestos fibers (and perhaps also refractory ceramic fibers). Nonoccupational (domestic or environmental) exposures to industrial asbestos fibers or to mineral fibers such as tremolite may also cause such lesions.

Asbestos-related pleural plaques are focal areas of essentially noncellular thickening of the (parietal) pleura; they are often bilateral and they may be calcified. They may occur even in people who have had only a light exposure to asbestos. It is generally accepted that the mere presence of asbestos-induced pleural plaques does not lead to symptoms or impairment and that such plaques are not precursors of a malignant evolution. However, pleural plaques may be considered as fairly specific biomarkers of previous asbestos exposure. Asbestos may also cause nonmalignant pleural effusions, diffuse pleural fibrosis, and round atelectasis.

Malignant mesothelioma is a pleural (or pericardial or peritoneal) tumor that is very specific for past asbestos exposure, either occupationally or environmentally. The latency between exposure and the manifestations of the tumor is usually 30 years or more; the tumor carries a very poor prognosis and may occur even after brief or low exposures. The incidence of mesothelioma has paralleled the industrial use of asbestos and its incidence will continue to increase until approximately 2010 to 2020 in most European countries.

*See also: Acute Respiratory Distress Syndrome. Asthma: Occupational Asthma (Including Byssinosis). CD1. Malignant Mesothelioma, Malignant. Occupational Diseases: Coal Workers’ Pneumoconiosis; Hard Metal Diseases – Berylliosis and Others; Inhalation Injury, Chemical; Asbestos-Related Lung Disease; Silicosis.*

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Coal Workers’ Pneumoconiosis

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Abstract

Coal workers’ pneumoconiosis (CWP) is defined as the non-neoplastic reaction of the lung to inhaled coal-mine dust. It is characterized by nodular and/or coalescent opacities on chest X-ray. Symptoms are usually limited to dyspnea in advanced stages of the disease. Computed tomography better defines radiological abnormalities. Simple CWP has no significant effect on spirometric measures, whereas lung function in the more advanced stages of progressive massive fibrosis (PMF) shows an obstructive and restrictive pattern. Pathologically, simple CWP is associated with the macular and nodular lesions, whereas complicated CWP is associated with PMF (opacity lesion of 1 cm in diameter or more) and the lesions of rheumatoid pneumoconiosis. No specific treatment affects the course of CWP, though treatment options are available for complications such as tuberculosis and chronic hypoxemia. Supportive care includes bronchodilators in patients with obstructive syndrome, routine vaccination, antibiotics for exacerbations, and pulmonary rehabilitation.

Introduction

Pneumoconiosis is defined as the accumulation of dust in the lungs and the reaction of tissues to its presence. The prolonged inhalation of coal-mine dust may result in the development of coal workers’ pneumoconiosis (CWP), silicosis, and industrial chronic bronchitis and emphysema, either singly or in various combinations. CWP is the term generally applied to interstitial disease of the lung resulting from chronic exposure to coal dust, whereas silicosis is due to inhalation of dust containing silica. The pneumoconioses differ in a number of ways from the acute allergic and toxic interstitial diseases that are associated with exposure to organic dusts, principally because of the long latency period (usually 10–20 years or more) between exposure and recognition of the disease.

CWP was first recognized in Scottish miners in 1830. In recent decades, the incidence of CWP has been declining in industrial countries due to improved dust controls, though increased mechanization in the mid-1960s led to a temporary increase in dust levels in some countries. Over the period 1950–80, the annual UK rate for the recognition of CWP for state compensation in working and retired miners decreased from about 7% to 1–2%. The overall prevalence of CWP in US coal miners declined from about 12.7% to 3.9% between 1969 and 1988, but there were substantial regional differences. The overall prevalence of simple CWP is 2.8%; the highest rate of 14% occurs in workers with 30 years or more of mining experience. Similar regional differences and similar declines have been noted in the US and other countries.

Etiology

Coal dust is not a mineral of fixed composition and comprises coal and quartz in various proportions. Coal is graded by rank, the rank reflecting its carbon content and thus coal quality and combustibility; anthracite is the highest ranked coal, with a carbon content of around 98%. Lower-ranked coals have carbon contents of around 90–95% carbon. The rank of coal has an influence on the risk of disease (higher-rank coals entail higher risk than lower-rank coals) and the progression of pneumoconiosis. Exposure to coal dust with a quartz concentration greater than 15% is associated with a high risk of a rapidly progressive form of pneumoconiosis that has the characteristics of silicosis. In open mines, dust levels rarely approach those of underground mines. Coal is currently actively mined in the US, UK, Western and Eastern Europe, India, China, South America, Australia, and Africa.

There are three groups of factors that are known to influence the character and severity of lung tissue reaction to the mineral dusts. The risk of pneumoconiosis is related to the intensity and years of exposure. However, among a group of workers exposed to the same dust, only a fraction develop pneumoconiosis, because of an individual susceptibility. The nature and properties of each specific dust constitute the third factor under consideration; for each mineral, geometric and aerodynamic properties, chemistry, and surface properties have to be considered. In order to cause pneumoconiosis, particles must be small enough (0.5–5 μm) to reach the respiratory bronchioles and be deposited there.

Pathology

The lesions of CWP are focal in nature. Simple CWP is associated with the macular and nodular lesions, whereas complicated CWP is associated with progressive massive fibrosis (PMF, opacity lesion of 1 cm in diameter or more) and the lesions of rheumatoid pneumoconiosis (Caplan’s syndrome). On gross