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THE MANY FACES OF ASBESTOS DISEASE

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Asbestosis is seen as one of the most significant medical problems deriving from industry in the present age. As not only asbestosis but also carcinoma of the lung and mesothelioma of the lung are accepted by the New South Wales Workers' Compensation (Dust Diseases) Board as compensable injuries provided that adequate industrial exposure to asbestos can be proven, it is important that all physicians should be acquainted with the three conditions and should, when they see conditions resembling carcinoma or mesothelioma of the lung, be alerted to make the fullest possible inquiries into the patient's industrial background and place of residence.

The presence of asbestos bodies in the sputum or in the lung tissue indicates only that the patient has been industrially or environmentally exposed to asbestos, and not that the patient has pulmonary asbestosis.

ASBESTOS is one of the most ancient and interesting industrial materials. Actually, asbestos is a name given to a series of minerals composed of silicates of iron and magnesium. Chrysotile is the main asbestos of industry, but amosite and crocidolite are also used.

The Romans mined for asbestos in the Italian Alps over 2,000 years ago, and Herodotus described in 450 B.C. how the Romans used asbestos for enshrouding corpses before cremation to permit of easy collection of the ashes for burial. Plutarch (A.D. 70) described how "asbesta" was used for the wicks of the lamps of the Vestal Virgins, the name "asbesta" meaning unquenchable, inextinguishable or inconsumable.

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It has only been during the last 50 years that asbestos has been used to any great extent for industrial purposes. World production of asbestos in 1880 was only 500 tons, whereas by 1950 production had increased to 1,200,000 tons.

Asbestos dust was not recognized as a dangerous hazard until 1900, when a case of asbestosis was described in a man who died in Charing Cross Hospital. By 1928 there were still only 10 cases of asbestosis on record.

Industrial exposure to the harmful effects of asbestos dust occurs not only in mining, but also in crushing and refining processes, textile manufacture, lagging, manufacture of brake linings and, very importantly in Australia, the manufacture of asbestos cement products.

Asbestos in recent years has come to be accepted as having significance not only in the industrial fields, but also in the larger field of environmental health. Contamination of city air by minute quantities of asbestos dust has caused great concern. Whereas long periods of exposure to high concentrations of asbestos dust are necessary for the development of asbestosis, mesothelioma of the pleura and peritoneum can occur after only minimal exposure of short duration. Fortunately, only crocidolite or "blue asbestos" has been positively incriminated as a cause, and although "blue asbestos" was used in New South Wales to some extent in days gone by, it is rarely used today, despite the fact that it is mined in Australia.

Ample evidence exists that asbestos is truly a ubiquitous material, as, for example, the fact that asbestos bodies were reported in 46% of autopsies in the Pittsburgh area in 1965 (Cauna *et alii*, 1965). Asbestos bodies are also found in the sputum of a large percentage of patients attending pulmonary clinics in industrial cities, without there being any evidence of industrial exposure.

The effects of asbestos on the human organism will be discussed under the headings (i) asbestos bodies, (ii) asbestosis, (iii) asbestos carcinoma of the lung and peritoneum, and (iv) asbestos mesothelioma of the pleura and peritoneum, although, to complete the picture, it should be mentioned that asbestos (amosite) is even of interest to the dermatologist, as "asbestos warts", showing histologically a picture of extreme keratosis, are commonly seen in asbestos workers.

ASBESTOS BODIES

The older textbooks frequently refer to the presence of asbestos bodies in the sputum and make no reference to the appearance of bodies in the lung tissue. Today, however, the presence of asbestos bodies in the lung tissue is frequently described and, in fact, thousands of asbestos bodies may be visible in a section of lung tissue not more than 1 cm² in area.

These unique bodies may vary in length from 20μ to over 200μ. An asbestos fibre forms the central core in each of the bodies, which are beautiful golden-yellow-to-amber coloured structures in a multiplicity of shapes. Beger (1933) showed that the asbestos fibres are coated with protein from tissue fluid until completely ensheathed, and that the granules within the gel coating are ferric compounds.

Typically, the asbestos bodies have an appearance like beads strung on a fibre, this being a result of surface tension effects. They are characteristically dumb-bell shaped.

The bodies appear to be innocuous, their coating of protein reducing their capacity to cause fibrosis. When asbestos bodies were injected intratracheally, no fibrosis was produced. The disintegration of the bodies increases their fibrogenicity.

Figure 1[1] shows a typical clumping of asbestos bodies in the lung tissue and surrounding diffuse fibrosis, which is markedly different from the more discrete areas of fibrosis seen in silicosis, with their typical whorled structure. Numerous phagocytes can be seen containing products of disintegration of the asbestos bodies.

It should be pointed out quite positively that the finding of even large numbers of asbestos bodies in the sputum does not necessarily mean that the patient is suffering from a degree of asbestosis which could be recognized clinically or radiologically, or which would cause even minimal disability.

I have deliberately described these bodies as "asbestos" bodies rather than the more commonly accepted "asbestosis" bodies, because I believe that the latter term is misleading, tending to indicate that these bodies are found only when there is a condition of pulmonary asbestosis.

ASBESTOSIS

It is not surprising that a number of cases of asbestosis are found in New South Wales, in view of the fact that a number of large asbestos plants manufacture a wide range of asbestos products in the Sydney metropolitan area. In these factories, control of the working environment has proceeded as more has been learnt of the human response to exposure to asbestos. Isolation of dusty processes, adequate exhaust ventilation and substitution of wet processes for dry have all considerably improved the work situation.

Unfortunately, many asbestos workers were exposed for long periods to hazardous concentrations of asbestos in the last two or three decades, and we are still seeing a considerable "back-log" of patients exposed during this time.

For the development of asbestosis it is necessary for the worker to be exposed to extremely high concentrations of dust for relatively short periods of time, or to lower concentrations of dust for much longer periods. Whilst in the development of any of the pneumoconioses there will always be some individual susceptibility, the development of asbestosis depends upon concentration multiplied by time. The recommended maximum allowable concentration of asbestos dust in the worker's breathing zone is set at 5 million particles per cubic foot, although local experience would indicate that control of the environment to this level does not offer adequate protection. In the spray application of asbestos to ceilings, concentrations of up to 200 million particles of asbestos per cubic foot have been found in Sydney. Without adequate respiratory protection, such as would be provided by an air-supplied respirator, asbestosis could be expected to develop in such a situation in an appallingly short space of time.

The presenting symptom of asbestosis is almost always dyspnœa. This occurs early in the disease, is conspicuous, and is practically always out of proportion to the signs found in the chest. There may or may not be a productive cough, but if there is, asbestos bodies may be found from time to time in the sputum.

Frequently, the patient may state that he has had repeated attacks of acute pleurisy, but in most cases no pleural effusion has occurred.

On clinical examination, abnormalities may be conspicuous by their absence. Occasionally cyanosis is noticed, but it is usually of slight degree. Clubbing of the fingers is found in some cases. Even when the condition is advanced, the percussion note is never seriously impaired, breath sounds are vesicular and a few rales and crepitations may be heard, scattered particularly at the lung bases. Some authors consider basal crepitations to be a constant finding in early asbestosis. I myself agree with Hunter (1969) ("Diseases of Occupation") that crepitations are heard in two-thirds of all cases of early asbestosis, but not in all.

Asbestosis is similar in its pathology to any other interstitial pulmonary fibrosis. Fibrosis interferes with gaseous exchange, and for this reason the most important pulmonary function test is carbon dioxide uptake.

In marked contrast to the usual absence of physical signs, X-ray examination of the chest often offers quite distinctive evidence of the disease, even before symptoms have developed.

Classically, in an advanced case all the following features will be found:

1. A ground-glass appearance, especially of the lower half of each lung. This may be sometimes difficult to detect, unless one places a ruler across the lungs and then compares the upper and lower halves.

2. A "shaggy" heart outline.

[1] For Figures 1, 2, 3 and 5 see art-paper supplement.

3. Obliteration of the cardio-phrenic angles.

4. Obliteration of the costo-phrenic angles.

5. "Tenting" of the diaphragm and other evidence of previous pleurisy.

Whilst all these features are seen in a classical case, one or more features may be missing. Opacities in the lung may resemble those of silicosis more closely than the usual ground-glass appearance.

ASSESTOS CARCINOMA OF THE LUNG AND PERITONEUM

Doll (1955) reached the conclusion that asbestos workers faced a risk of cancer of the lung 10 times as great as that faced by the general population. In one series, 18% of 365 patients with asbestosis had cancer of the lung. The carcinogenic effects of asbestos are not confined to the lungs, for Keal (1960) found a high incidence of peritoneal carcinoma in women with asbestosis. It is thought that when asbestos fibres are inhaled and swallowed, they may penetrate the bowel wall to involve the peritoneum.

It has also been reported that the possibility of carcinoma of the lung in asbestos workers is greatly increased in those who are cigarette smokers.

Carcinoma has occurred in industrially exposed asbestos workers even though a recognizable degree of asbestosis could not be confirmed by X-ray examination. In most cases a considerable number of years (between 30 and 50) has elapsed from the time of first exposure to asbestos until the discovery of the tumour, and in other cases carcinoma has appeared many years after exposure to asbestos has ceased. In all the cases in my experience, the patient had reached, or was approaching, retiring age.

Careful environmental control should practically eliminate this tumour as a problem in asbestos factories, as it has been shown to be related to high dust dosages.

A typical asbestos carcinoma is shown in Figure 3.

ASBESTOS MESOTHELIOMA OF THE PLEURA AND THE PERITONEUM

Such an asbestos scare has been stirred up overseas by reports which confirm the relationship of the development of mesothelioma of the pleura and peritoneum to contamination of air with asbestos, not only in the working environment, but also in city air adjacent to asbestos works, that an article in *Prevention Magazine* in July, 1967, suggested that it might be unsafe to visit Expo '67 because of the risk of asbestos in the air.

It might be wise, therefore, to allay immediately any fears that inhaling the air of the city of Sydney is likely to cause a great epidemic of mesothelioma in the future. Practically all asbestos mesotheliomas reported overseas have occurred as a result of exposure to only one variety of asbestos, namely, blue asbestos or crocidolite, and not with amosite or chrysotile. As previously stated, the use of crocidolite has been virtually eliminated in the New South Wales asbestos industry. In the two confirmed and one unconfirmed cases of mesothelioma seen in New South Wales since the new *Workers' Compensation (Dust Diseases) Act* was put into operation, there had been a definite period of exposure to blue asbestos more than 20 years earlier.

Mesotheliomas are primary tumours of the serosal surfaces, and the first was described by von Rokitansky in 1854. Von Rokitansky called the growth a "colloid cancer" of the peritoneum.

There was much disagreement amongst the experts until Godwin (1957) set out strict criteria for the diagnosis of pleural tumours, and Winslow and Taylor (1960) did the same for peritoneal tumours. Since these two dates the diagnosis of mesothelioma has become much more common. Borow (1967) states that the incidence of primary mesothelioma has varied statistically from 0·02% to 0·2% of all autopsies, with a ratio of 1:2 in favour of the male.

The Pneumoconiosis Research Unit at Johannesburg, South Africa, described, in 1957, the first large series of cases of diffuse mesothelioma diagnosed histologically. Wagner *et alii* (1960) were able to establish that 33 of their original series of 33 patients with proven pleural mesotheliomas had been exposed to crocidolite in or around the Cape of Good Hope asbestos fields or in industry. Some patients had left the area of exposure as young children, and the average period between exposure and development of the tumour was 20 to 40 years. Wagner later extended his study until he had diagnosed a total of 87 pleural and two peritoneal mesotheliomas, and in only two of these cases was he unable to establish a history of asbestos exposure. The diagram in Figure 4, reproduced with the permission of the *Archives of Environmental Health*, was taken from an article by Lieben and Pistawaka (1967).

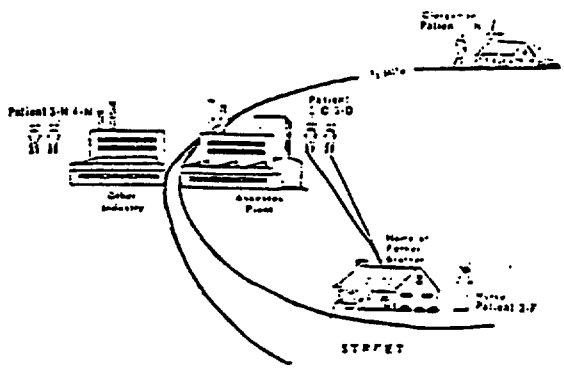

FIGURE 4: Patients 2-N and 3-N both had pleural mesotheliomas, while 4-N had a peritoneal mesothelioma. Patient 2-F, a nurse, had no history of industrial exposure but her father and brother had worked in an asbestos factory for many years. Patients 2-O and 3-O had both had more than 20 years' exposure applying asbestos insulation, and both had pleural mesotheliomas. This diagram depicts quite strikingly the danger of working in asbestos factories, working adjacent to such factories, working within the area in which asbestos dust could "fall out", or even of coming in contact with the asbestos-contaminated clothing of a relative.

Figure 5 shows the radiological appearance of a pleural mesothelioma in a person who worked for nearly 30 years in an asbestos cement works in New South Wales.

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Special Article

DATA PROCESSING FOR A RESEARCH PROJECT

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The development of a system of electronic data processing for the Queensland Melanoma Project is described, and the plan of the system is discussed.

EFFICIENT data processing is not something that comes easily to clinicians. At the outset of most clinical investigations the information is tabulated by hand and counted laboriously. As the investigation proceeds and it becomes evident that the initial methods are unsuitable, the next method used is that of punched cards sorted by means of a knitting needle. There the process often stops. The mass of data accumulated by this time may become overwhelming, so that an attempt is made to convert the findings for computer analysis.

At this point difficulties become apparent. It is hard to find people with the time and knowledge to design a system and computer programmes suitable for medical work and to have this work done within the limits of a research budget.

In the Queensland Melanoma Project we have passed through all these stages. A report on how the difficulties were overcome, and an outline of the present methods of data processing, may be of help to other clinicians unsure how to proceed in this problem.

In the first two years of the Project, data handling was limited to relatively unsophisticated methods. Hand-written records provided the only master file of information about the patients; follow-up letters were typed after the hand-sorting of records; and analysis of information was done with a punched-card sorting system which proved both cumbersome and liable to error as the numbers of patients increased.

It became apparent that much more efficient methods of data processing were necessary. The volume of basic information and the vast amount of up-dating necessary warranted the use of a computer-based system for filing and analysis. Because of this relatively late decision, the methods of data processing had to be developed for the existing structure of the Project. Most of the problems experienced occurred in the early stages. Once experience was gained in analysing requirements we were able to progress much faster.

In developing the methods, it was considered wise to plan a system which could be used specifically for the work of the Project, but which, without alteration, would be suitable for use for many other medical information processing purposes.

We required our system to perform certain major functions. These were:

1. To establish a file of the information concerning each patient, including (a) patient's name and address, (b) name and address of doctor responsible for the patient, (c) all clinical information concerning the patient.

2. To be able to update the file by (a) checking the correctness of presentation of all new information, (b) adding information about new patients, (c) altering pre-existing information by changing addresses, responsible doctor or clinical information, (d) adding new clinical information to existing records, (e) deleting records where required.

3. To use the file to select patients requiring follow-up and automatically prepare the follow-up letters.

4. To analyse the information in any manner considered desirable.

FACILITIES

Part-time usage of established equipment for short periods is all that is required. The following facilities are available:

1. Card-punch facilities for transferring the information from code sheets to "Hollerith" 80-column cards (available

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