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ASBESTOS BODIES AND BIOEFFECTS—
A DETECTIVE STORY

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As an introduction to this Detective Story, I should like to point out that no one disputes the importance of placing on "trial" materials suspected of producing hazard to health in order that adverse bioeffects of such exposures as may occur in man's working and living environments may not escape notice but be detected and controlled by appropriate and effective means, common to good Industrial Hygiene practice.

This paper is an outline of the history of the asbestos body from its first discovery through a period when it was considered of little clinical significance to the present day when it holds the central position in what some people suggest could be one of the greatest industrial medical problems of the age.

First, let me outline some of the terms that are going to be used in the course of this presentation:

(1) Asbestos—This is a general term that covers a number of fibrous minerals of which four types are of commerical importance. These are brocidolite or blue asbestos from South Africa. Amosite which is red in color and is also mined chiefly in South Africa, chrysotile which is white and occurs in many countries of the world, and anthopholite which is also white and is mined mainly in Europe. The importance of this will become apparent when we discuss the finding of asbestos bodies in the lungs of the urban population in the North American continent.

(2) Asbestosis—This is a type of lung fibrosis that occurs in workers exposed to large amounts of asbestos dust. It may or may not be associated with recognizable clinical disease during life, and is produced by all types of asbestos.

(3) Bronchial carcinoma—This is the layman's lung cancer that we know is associated with heavy smoking and has also been found to occur frequently in workers exposed to large amounts of asbestos dust. Again, this tumor appears to be associated with all asbestos types.

(4) Mesothelioma—This is a very rare tumor that develops from cells lining the chest and abdominal cavities. These tumors so far appear to be associated with exposure to only one type of asbestos, i.e., brocidolite which as has been noted is blue and is mined chiefly in South Africa.

Gloyne in 1932 demonstrated that each body consisted of an asbestos fiber as a core with some coating material around it and it was suggested that this coating might have the function of protecting the tissues from the harmful effects of the mineral. This led to the term asbestos bodies being substituted for asbestosis bodies and there the situation remained until quite recently. The bodies, it was thought, only occurred in relation to asbestos and were regarded as diagnostic of exposure to this dust but not any real indication of disease.

This situation was only changed by the report of Wagner in 1960 that the rare pleural tumor, the "mesothelioma," was in South Africa associated with exposure to blue asbestos or crocidolite in the mining areas. The association of ordinary bronchial carcinomas with exposure to asbestos dust had long been recognized, but it has recently been shown that this is related to high dust dosages in asbestos workers and careful environmental control has almost eliminated this tumor as a problem in factories. Wagner reported, on the other hand,

that many of his cases had never worked in the mines, but had only lived in the mining areas and indeed may only have lived in these areas for a year or two, often as children. He also showed that the time lag between last exposure and tumor formation was always long and averaged 40-50 years.

This discovery presented entirely new problems. While asbestosis and bronchial carcinoma were obviously connected with severe dust exposure, these were solely problems for the asbestos industry; but if a very small amount of dust could cause a mesothelioma, might not asbestos products be a hazard to the whole population?

Since the presence of asbestos bodies in the lungs was considered the best way of demonstrating asbestos exposure, it was logical to examine the lungs of normal members of the population for the presence of these bodies and the first report on one of these studies was published by Thompson in 1963. He found 26% of autopsy cases in Capetown contained what appeared to be asbestos bodies. Since then, several other studies have been completed including one by Cauna, Totten, and Gross in 1965 which reported that 46% of autopsies in the Pittsburgh area contained bodies. These results led to the suggestion in some circles that although less than 600 cases of mesotheliomas have so far been reported in the medical literature of the whole world, the increase in asbestos consumption in recent years might produce a great epidemic of these tumors in the future.

These reports have in fact received great publicity in the press and have led some people to suggest that the use of asbestos should be banned altogether. This very year an article appeared in Prevention Magazine suggesting

that is might be unsafe to visit Expo '67 because of the risk of contamination by asbestos in the air based on Dr. William M. Thurlbeck's findings.

This asbestos scare has, however, ignored some of the published facts on mesotheliomas and new information suggests that others cannot be taken at their face value. First, asbestos is not a single mineral. Wagner reported quite distinctly that his mesothelioma cases were associated with the crocidolite areas and he found no cases associated with either amosite or chrysotile. In other countries attemps to demonstrate that exposure to dusts other than crocidolite could produce mesotheliomas have so far been almost completely unsuccessful. The mesothelioma problem is therefore, not as far as we can see at the moment, one that involves the whole asbestos industry, but only users of crocidolite and, fortunately, this mineral represents a relatively small proportion of total world asbestos consumption.

As regards the dosage required, we must examine the conditions in the South African mining areas from which Wagner obtained his cases. In these mining areas it is common practice to surface roads with the waste rock from asbestos mining and the rest of this material is deposited in dumps. Wagner states that some of his cases played among these dumps as children and others no doubt drove along the roads with car windows wide open. These cases, therefore, although they may have had a very low exposure by industrial standards, probably inhaled far more dust than could every be met by members of a normal urban population.

Finally, we must reconsider the evidence for the exposure of the normal urban population to asbestos dust, and this means reexamining the position of

of the asbestos body in this problem. These bodies were for many years believed to be formed only around asbestos fibers, but recently evidence has accumulated that the deposition of a similar coating can occur around a number of materials, and studies have been undertaken in the Mellon Institute and in the United Kingdom in an endeavor to find out just how many materials will produce asbestos-like bodies, and also to attempt to discover the chemical processes involved. In order to discuss this work, it is necessary to summarize what is know about the structure and chemistry of genuine asbestos bodies.

Gloyne in 1932 had demonstrated that the body coating contained iron and Beger in 1933 had shown that protein material was also involved. The presence of iron in the capsule has led to Perl's stain being used as an aid in finding these bodies. The capsule stains dense blue and is more easily seen in tissues than the natural brown color. When we first examined the structure of asbestos bodies in the electron microscope, we found that the coating was made up of small dense granules about 60 A° in diameter. Similar granules had previously been reported in a number of tissues and it had been assumed that they represented either ferritin or haemosiderin. Since this tied in well with the known iron protein nature of the capsule, it was suggested that the asbestos body coating was made up of one of these chemicals. As regards the anatomy of the bodies, it was found that although sometimes only one dense layer of coating material was present, in other cases, the coating consisted of a number of different layers of varying thickness and density. Occasionally the outermost layer was made up not of granules but fine filaments

about 60 A° in diameter which we now believe to represent calcium deposits.

For the experimental production of bodies with non-asbestos materials, two techniques were used. In Pittsburgh hamsters were injected intratracheally with the dust, while in Cambridge we used intrapleural injection. The dusts used were aluminum silicate, glass fiber, carborundum, man-made textile fiber and elastin. In both injection sites all these foreign materials produced bodies which with the light microscope appeared very similar to asbestos bodies. That is to say they were golden brown in unstained sections and were often segmented. Perl's stain showed that the coating contained iron in common with asbestos bodies. For this reason Dr. Gross in Pittsburgh suggested the term "Ferruginous" body and suggested that this general term should be used for all bodies found in human lungs at least until the mineral involved was positively identified. In Cambridge we have been attempting to examine these bodies with the electron microscope to see how their fine structure compares with genuine asbestos bodies and have some interesting results although the difficulties of cutting thin sections of tissue containing glass fiber or aluminum silicate have so far precluded getting photographs of the quality that we did with genuine asbestos bodies. However, it is clear that whatever the foreign material that stimulates the production of a "Ferruginous" body, the coating consists of small dense granules approximately 60 A° in diameter. The coating is usually in the form of a single layer, but in some cases, as with asbestos, a layering effect can be seen. This layering is especially noticeable with elastin bodies. In the case of this material, however, the process involved is slightly different since the granular material is deposited inside the large elastin fibers and not around the outside. This appears to be some form of impregnation that starts

at one point and works inwards until the whole elastin fiber is impregnated.

The situation at present is then that we must not assume that "Ferruginous" bodies seen in the lungs of the normal population are asbestos bodies until their mineral core has been definitely recognized. Almost the only method of identifying these small particles accurately is by electron diffraction and this involves a very great deal of work in manipulating the small bodies on to an electron microscope grid. However, in Dr. Gross' laboratory, a study of these structures has commenced which we hope will give an indication of what percentage of human "Ferruginous" bodies are caused by asbestos.

Summary

Asbestos has been related to certain bioeffects which appear specific and are dose related. These effects include asbestosis which will occur in almost all exposed persons if sufficiently high exposures are maintained for long enough periods. In addition, some individuals so exposed develop bronchial carcinomas. Industrial Hygiene practices have been very effective in controlling both these forms of occupational disease.

There has been recognition for many years that workers exposed to asbestos dust develop "asbestos bodies." First observed in individuals who had asbestosis they were called "asbestosis bodies" but when it became evident that they frequently occurred in the absence of this disease the name was changed to asbestos bodies.

The current furor over asbestos bodies results from two developments which recently appeared in the professional literature and were widely reported in the news media with varying degrees of sensationalism. This has resulted in considerable public apprehension on an international scale. These developments were firstly Wagner's study of mesothelioma cases associated with crocidolite asbestos exposure often non-occupational in nature.

Thompson's conclusions that asbestos is a significant urban air pollutant based on his findings that over 26% of urban dwellers can be shown to have asbestos-like bodies in their lungs.

Because of this, some individuals have expressed the opinion that asbestos should be withdrawn from many of its uses, e.g., in brake linings. However, the basic assumption that asbestos like bodies can only be produced from asbestos has proved incorrect and this casts considerable doubt on the theory that has been the chief basis of the asbestos "scare."