

THE BIOLOGICAL EFFECTS OF ASBESTOS
ON THE HUMAN ORGANISM

A

Extremely good paper
- good references
and organization
- very informative
and well presented
in class

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course grade = (A)

In this paper I intend to discuss the biological effects of asbestos on the human organism. It is necessary then, to define asbestos, its uses and those who are affected by it since scientific investigations have recently proven that there is an association between the inhalation of asbestos and pulmonary fibrosis, bronchial carcinoma, mesothelioma of the pleura and gastro-intestinal tumors. I will discuss these diseases first in relation to their occupational exposure (because most of the research is in relation to the occupational danger.) Finally, I will discuss the environmental risk of asbestos to the general population.

Asbestos is one of the most ancient and interesting industrial materials. Actually asbestos is the generic name given to several varieties of naturally occurring fibrous mineral silicates of iron and magnesium. The Romans mined for asbestos in the Italian Alps over 2,000 years ago (1) and Pliny the Elder describes shrouds of woven asbestos used in cremation of the nobility. Plutarch records "perpetual lamp wicks" in the temples of vestal virgins.(1) And it is said that Charlemagne amazed his guests by tossing an asbestos table-cloth into the fire to be cleansed. Marco Polo reported asbestos cloth in Central Asia.(2)

The modern asbestos industry began with the working of an Italian mine in 1868 and the industrial uses of asbestos fibers have multiplied following the discovery of large deposits of chrysotile (white asbestos) in 1880 in Quebec, Canada. Chrysotile is one of the four main types of asbestos minerals. It is a hydrated magnesium silicate and makes up about 90% of the world's output of asbestos.(1) Its fibers are soft and suitable for textile manufacture and other commercial uses. It is mined

principally in Canada and Russia and a small portion is found in South Africa.

Crocidolite, a second asbestos mineral is chemically similar to chrysotile but iron replaces magnesium in the molecule. Its fibers have a high acid resistance and its main source is the Cape of Province of South Africa and Australia. Amosite, another asbestos mineral is a ferrous silicate and mined only in South Africa. Finally, there is anthophyllite which contains both iron and magnesium in its molecule. Mined in Finland and Italy, this is the asbestos least commercially used.

It is important to mention these different types of asbestos because the various biological effects of asbestos may be dependent on the type of fiber to which the individual has mainly been exposed.(3)

Presently the world consumes over three million tons of asbestos per year. In 1935 the United States alone imported 501 tons of chrysotile and in 1962, 726,268 tons. (4) These statistics are vital since malignancies now being reported are related to the consumption and use of asbestos in a much earlier time period. The health problems in the future may be serious and extensive to to the 1962 figure.

In addition to the figures concerning consumption, there are over 3,000 separate uses of asbtos being reported. The reason for this some 3,000 different applications is due to the unusual properties of asbestos. For example, it is resistant to heat, friction and acid. It has great flexibility, tremendous tensile strength and is relatively cheap to produce. Therefore its uses are many and varied.

Asbestos is used in cement products, fire-proof textiles, brake linings, gaskets, asbestos paper, roof tiling, insulation of pipe and duct systems, insulation of turbines, boilers and marine construction and repair.

These serve to illustrate just a few examples of the many uses of asbestos.

Therefore, due to the numerous number of uses of asbestos, obviously there will be a huge number of people working with asbestos. And here is where the problem lies. Through a history of scientific investigations, it has been proven that the inhalation of asbestos can be dangerous to the human organism and eventually result in death. Asbestos exposure, occupational and non-occupational is becoming increasingly more important as multiple biological effects associated with exposure to asbestos are recognized.

I will briefly examine a few of these occupation exposures. Since asbestos is mined both in open cast and deep mines, there is drilling and explosives when the rock is extremely hard. During the process, the large amounts of fiber dust escape into the atmosphere and the miners naturally inhale the dust.(1) In fact, the oldest research of asbestos is with the miners.

The next largest group affected is probably the insulating workers which encompass many different trades. (It should be noted that insulation workers include most of the work in commercial buildings, heavy industrial building and marine construction.) Insulating workers as a whole learn to do all the major jobs in their trade and most in the U.S.A. have worked in their trade for 20-25 years. In an analysis of the insulating workers environment, they are predominantly working with calcium silicate and magnesium carbonate insulating material containing asbestos fibers.(5)

These are only two different groups, but there are many more people involved, for example: those in the manufacture of fire-proof textiles,

cement products, brake linings made of asbestos would also be involved in this process of exposure to asbestos through inhalation.

Here then, is the main point of my investigation. Through inhalation of asbestos, biological effects are now being recognized as directly associated with exposure to asbestos. Those biological effects now researched are: Asbestosis, chronic pneumonitis, emphysema, chronic pleuritis, pleural plaques, cor pulmonale, carcinoma of the lung, diffuse mesothelial tumors of the pleura and peritoneum, gastrointestinal tumors and ovarian tumors.

In this paper, I will deal with four of these effects which I feel are the most widespread and have been most thoroughly researched. These are pulmonary fibrosis (asbestosis), carcinoma of the lung, diffuse mesothelioma of the pleura and gastrointestinal tumors.

Asbestosis is a type of pneumoconiosis contracted by the inhalation of the fine fibers of asbestos.(6) Fundamentally, an occupational hazard, it was first recognized in the early 20th century and became a scheduled disease in 1931 in England when cases began to receive compensation.(7) Research into the condition was carried out then but use of asbestos increased and recent investigations have found the problem to be much greater.

Recent clinical experience indicated that the appearance of asbestosis (pulmonary fibrosis) is dose-dependent. Children have died of asbestosis and cor pulmonale after a few years of an overwhelming exposure "within large shipping bags trampling down fluffy amosite asbestos which all day long came cascading down over their heads."(8) Sluis-Cremer gives an average in one factory in South Africa of six years at work before asbestosis was manifest. Jacob and Anspach in Dresden determined an over-all average

of thirty years before the asbestosis became disabling.(17) X-ray changes are induced in most cases after 20 years employment as an insulator.(9)

While long latency is usual and generally there is progression of the fibrotic process long after removal from contact, there is little information and quantitative data on the dose which each individual was exposed to. Lung clearance studies indicate a marked difference in the effects of short, heavy dust exposures compared to minor, low exposures.(8)

A modern researcher of asbestosis, Dr. Selikoff of Mt. Sinai Hospital in New York, in his study and examination of 1,117 insulation workers emphasized and demonstrated the importance of the interval of time from initial exposure and the date of examination as a factor in the detection and recognition of asbestosis. He found the percentages of asbestosis increasing with the longer time interval between exposure and examination.(4)

Pleural calcifications, primarily of the parietal pleura and bilateral pleural calcifications have been generally concluded to be directly associated with asbestosis. Therefore pleural calcifications may serve as an indication of previous asbestos exposure and lead to discovery and recognition of cases of asbestosis.(4)

The symptoms of an advanced condition of pulmonary fibrosis are breathlessness or exertion, a productive cough and cyanosis is common. It must be noted, however, that there has been cases of a patient with a limited pleural plaque, where there is not disability and it is assumed that the fibrosis did not spread.(9)

It is essential then to recognize asbestosis and its related group findings, but it is even more important to detect early damage to the lung if the pathological effects and disability from exposure to asbestos is

is to be lessened or prevented.

Another threat from asbestos lies in its possible association with lung cancer. Cancer of the lung occurs more frequently in those with occupational exposure whether or not they develop fibrosis.(10)

In 1935 Lynch and Smith reported the first case of asbestosis and lung cancer.(11) The probable relationship was finally confirmed by Doll in 1955 in a study of employees of an asbestos textile factory. He concluded that lung cancer is a specific industrial hazard for men employed for 20 or more years in scheduled areas with incidence ten times higher than that of the general population.(3)

Since Doll there have been more studies that emphasize the advisability of observations over a long period of time. One study, however, by Brown and Truan in a study of Canadian miners, indicated a negative association between lung cancer and asbestos exposure and cast a doubt on the relationship.(4)

Mancurso in 1942, studied workers engaged in the manufacture of asbestos brake lining and observed a definite association between lung cancer and this exposure to asbestos. Also in his study, he noted the inherent limitations of the study of Brown and Truan and that the negative conclusion was not justified.(4) Enterline added to this study with his investigation of mortality of workers employed in the asbestos production industry compared with those in the textile industry. He observed a higher rate of lung cancer.(5)

Selikoff in a long term study of insulation workers with a history of 20 or more years since first exposure to asbestos dust found that death rate from cancer of the bronchus and pleura was 6.8 times as high among

these asbestos workers as in the general United States white male population. Selikoff also analyzed the smoking history data and concluded that "unusual smoking habits can not account for the high death rate from lung cancer among these workers." (10)

The conclusion of all these studies is an association of asbestos with lung cancer. What scientists do not know, however, is whether asbestos has properties of primary carcinogenicity or whether its effect is entirely synergistic. One hypothesis proposed by five cancer researchers as a result of an intense study into the role of trace metals in chemical carcinogenesis is as follows: Asbestos per se plays a passive role in carcinogenesis; the active role is taken by the trace metals with which it is associated. Benzopyrene or related hydrocarbons, derived from external environmental sources or from asbestos itself, is the carcinogen. Whether cancer develops depends on the residence time of the unmetabolized benzopyrene in the host and the inherent susceptibility of the host. On the basis of the hypothesis, trace metals commonly associated with lung cancer should inhibit the metabolism of BP increasing the residence time and the risk of cancer; trace metals naturally occurring in the host and not commonly associated with cancer should accelerate the metabolism, thus ridding the lung of the carcinogen and the risk of cancer. (12) It is only one hypothesis of course.

This theory that other factors must potentiate the asbestos exposure has also been proposed by Selikoff and Hammond when they showed that asbestos insulators who smoke have about 90 times the incidence of lung malignancy of smokers who are not exposed to asbestos. They too deduce that "the metal complexes in the asbestos fibers (nickel, chromium, etc.)

benzopyrene and other carcinogenic agents absorbed on the asbestos, allergic response which produces altered immunity and the increased burden from urban populations or smoking are now postulated to be the major cofactors which make asbestos carcinogenic."(13)

Another biological effect "is the growing evidence linking mesothelial tumors both of peritoneum and pleura with exposure to asbestos, apparently of slight degree or remote in time, constitutes one of the most serious aspects, particularly from a public health point of view, of the asbestos problem."(14)

A mesothelial tumor of the pleura and peritoneum is an extremely rare tumor. These tumors have sarcomatous invasive growth characteristics and extend rapidly within the pleural cavities to produce multiple implants throughout the affected side and sometimes totally fill the pleura space with a gray-white, fleshy neoplastic tissue.(6)

It was first diagnosed in 1960 by Wagner and Sleggs who reported an association of pleural mesothelioma with asbestos exposure. They investigated 33 cases of diffuse mesothelioma in the North Western Cape Province of South Africa (an asbestos-producing area) and in 32 cases demonstrated at least suggestive evidence of potential asbestos contact, usually non-occupational, as for example residence in an asbestos area.(15) Since this report, diagnosis of pleural mesothelioma has been a signal to seek previous asbestos exposure,

Newhouse studied a series of mesothelial tumors in London. Besides the actual occupational exposures, he traced some to living within $\frac{1}{2}$ mile of an asbestos factory and some cases where dust was brought home by relatives working with asbestos.(3)

The common observation of a mesothelial tumor is the frequency of a very long latent period. It may average 40 years with a history of limited exposure to asbestos and minimal fibrosis or complete lack of asbestosis. The patient with mesothelial tumors of the pleura suffers severe upper abdominal pain because the tumor may infiltrate the chest wall. The course of the disease is rapid, it averages two years from onset to death. Asbestos workers frequently die of mesothelioma since malignant diffuse mesothelioma is almost always a fatal disease. Very few if any respond to radiation therapy and no other treatment appears to have any effectiveness at all.(10)

In the early beginning of research of the association between mesothelioma tumor of the pleura and asbestos fiber, scientists believed crocidolite to be the only source.(1) Now, however, the current opinion is that though Wagner's report is based on crocidolite asbestos fiber, it is not the only form of asbestos that induces mesothelioma. Other types are suspect.(16)

Also there appears to be a biological effect between asbestos and gastrointestinal tumors. Dr. Selikoff and his colleagues in 1964 were investigating the causes of death of over 1,500 insulation workers in New York and found that as well as high rates of asbestosis and cancer of the lung, cancer of the gastrointestinal tract was 3 times as common as the general population.(9)

For the most part, however, observation of gastrointestinal tumors in individuals exposed to asbestos is very limited. In mortality studies, peritoneal mesotheliomas are included and may be responsible for the higher than expected findings.(4) A relatively large number of cancers are

coded on the death certificate as "primary site unknown." In many instances, the correct information can not be obtained and therefore accurate assessment of the specific organs involved is difficult.(4)

Finally, in conclusion of the discussion of biological effects, many more studies have been made in the association of asbestos with damage to the human organism. A few of them are as follows: Konig first observed, in an autopsy study, a possible relationship of stomach cancer and asbestosis.(17) Selikoff and Hammond observed high rates for cancer of the stomach and for cancers of the colon and rectum.(14) Mancurso found rates higher than expected for cancers of the stomach, large intestine and rectum.(4) Of course I could not begin to discuss all the studies done on this subject since they are so many. I think it is important though, to discuss the preventions of exposure to asbestos inhalation especially for the worker since most of the studies in this report thus far have dealt with the worker.

Primarily, a greater awareness of the health hazards associated with exposure to asbestos is needed on the part of those employing asbestos workers in order that they may minimize work exposure and provide necessary medical surveillance.

Concerning prevention, there are primarily two schools of thought. Some asbestos researchers think that masks, respirators and protective clothing should be worn in order to prevent inhalation of dust. However, the majority feel that all measures should be taken to prevent even the escape of harmful concentration of dust. They feel that dust masks and respirators are an "admission of defeat in controlling the environment."(3) With good dust control, personal protection should not be necessary (though

they do admit those devices ought to be worn as a secondary defense measure and in certain situations like stripping and lagging in confined spaces, it may be necessary for the worker to wear a mask.) (9)

There is reason to believe that occupant use of asbestos fiber can achieve some degree of safety, just as the safety achieved with explosives, radiation and beryllium although extensive alterations are required in the control of production and manufacturing of the contaminant so that none escapes to the outside and there is proper disposal of solid wastes containing the fiber.(18) This should be combined with strict codes of practice for the workers.

In the past, many materials have been found to have unexpected risks and damages, these are found, however and the risk ceases.(18) This has proved rather inadequate in the past concerning asbestos because the wide range of occupational hazards was not legislated. Recently since measures have been taken to reduce the dust in the atmosphere by forced ventilation, the incidence of disease has fallen. There are no actual statistics on this point because actual legislation and mandatory protective measures have taken place within the past three years.(1)

Finally, I think it is extremely important to discuss the biological effects of non-occupational exposure of asbestos fibers, because this would naturally affect a much greater number of people.

It is a proven fact that people with no occupational exposure harbor asbestos bodies in their lungs.(10) This is surely a consequence of the extensive use of asbestos in our society.

Asbestos fibers when in the lung have the capacity of becoming characteristically coated. These fibers form asbestos bodies which when seen

"can hardly fail to attract attention." This was so even before asbestos disease was known. Thompson used this study to demonstrate the frequency of inhalation of asbestos by the general public. He examined smears of lung bases in 500 consecutive autopsies in Cape Town and in 26.4 per cent found asbestos bodies.(10)

Another study was done in 1965 in Miami Florida on 500 consecutive autopsies of 15 years or over. In the great majority of these cases including all the females, the asbestos bodies, though scanty, were regarded as the result of contamination of the urban atmosphere by asbestos. The research team that carried on this study suggested that both air contamination and industrial exposure to asbestos was likely to increase in view of the increasing consumption and diversity of the uses of asbestos and asbestos-containing products and of its virtual indestructibility.(19)

A very recent study was done in March of 1971 in New York City concerning this issue. Electron microscopy showed chrysotile asbestos to be present in all examined, (28 of 28.) The asbestos often occurred in association with other substances including particles of clay or talc, fibrous glass and occasionally diatoms. The point is that asbestos is unequivocally present in the lungs of urban dwellers.(20)

All of these studies found asbestos bodies in the lungs of people who did not directly work with asbestos material. A serious question is then raised. Does the inhalation of presumably small amounts of asbestos carry a risk of widespread community asbestos disease?

Actual evidence to answer this question does not seem to be uncovered at this time, but there does seem to be two different hypotheses based on similar assumptions.

One hypothesis is proposed by I. R. Tabershaw in an article he wrote for the Journal of Occupational Medicine in 1968. He acknowledges that asbestos minerals increase the risk of lung cancer in occupational groups and that asbestos bodies found in routine autopsies are due to asbestos; but he does not feel one is justified in concluding that asbestos is a major threat to public health. He concludes this from four basic assumptions; much of world tonnage goes into uses that do not lead to air contamination; asbestos is not actually indestructible, that the effects are dose-dependent and that low doses probably lead to lower rates and longer latency. Biological studies centered on the meaning of the asbestos body are crucial. Strict control of industrial and neighborhood environments is essential, but it is "premature to extrapolate from the effects of heavy exposures to minor and low level of exposures,"(8)

Dr. Selikoff, on the other hand, who has done extensive research on this subject indicates that asbestos is widely disseminated into the general community from industry sources or end-product use, that such dissemination may produce detectable disease; and that methods to study the question must be designed. The important thing is that having extensively studied asbestos inhalation of insulation workers and having investigated studies of non-occupational exposure, he can not rule out a danger to the general population.(10)

The answer to these equally intricate problems will require new approaches and diligent efforts. Research must be funded on the mode of the asbestos fiber. Its carcinogenic properties and the properties of the different types of asbestos should be studied. Also there ought to be studies to determine the more susceptible groups with the highest risk.

The implications of this study are vital. It is rather frightening to think that a material men have used for literally 2,000 years is now found to be a potential killer. What materials we now use everyday and are disseminated into our environment will be found to have carcinogenic properties in the future??

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