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MORBIDITY AND PATHOLOGY OF LUNG CANCER DUE TO ASBESTOS

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the whole thing.

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Reports of four cases of lung cancer among asbestosis patients of the Dresden asbestos industry (Jacob and Bohlig) were followed by publication on the subject of lung cancer due to asbestos in which various conclusions were drawn.

Rombola in his 1955 report on the first case of asbestos-induced lung cancer observed in Italy voiced extremely skeptical views concerning the increased probability of asbestos patients developing lung cancer and justifiably requested that further experiments be undertaken to determine the exact correlation. On the other hand, Doll, based on the autopsy statistics of 105 persons previously employed as asbestos workers in England and including 75 cases of asbestosis, found a total of 15 cases of lung cancer, giving an incidence of lung cancer due to asbestos among asbestos workers which is ten times that of the general population after a minimum exposure of 20 years.

Contrary to this extremely high risk allegation, Doll himself was unable to gather more than 61 cases of lung cancer due to asbestos from worldwide literature prior to the year 1955. However, these include cases where the asbestos workers were found to suffer from bronchial carcinoma but not necessarily from asbestosis (Cartier: 3 cases) and Doll's own cases include three of lung cancer without asbestosis!

Since with regards to the genesis of lung cancer due to asbestos most authors do feel that the development of cancer shares a common origin with asbestosis, i.e. that these are the result of mechanical irritation due to the asbestos needles and asbestos particles retained in the lung tissue (Baader, di Biasi, Holstein, Noro, Merewether, Sundius, Bygden),

the possibility of a causal correlation must be rejected at least as far as the autoptically unconfirmed cases of asbestosis are concerned.

If we add Doll's 15 cases to the 61 cases mentioned in the literature, excluding the six cases without asbestosis, we find that the literature thus contains 70 cases of lung cancer due to asbestos. To these 70 cases we add five of our own (see below) and five cases reported by Weiss, Leicher, Stoll et al., Isselbacher, et al. and Rombola which are not included in Doll's source information.

There were therefore a total of 80 cases of lung cancer reported in world literature over a period of 20 years. In 1956, Hueper compiled 112 cases from the world over but without source information so that it was impossible to determine whether any of our 80 cases were included. The authors were only able to obtain detailed data on lung cancer due to asbestos in the United States in 20 cases reported by Gloyne as well as Lynch and Smith. Most of the reports originated from England. In Finland (Noro, Wegelius) and Denmark (Frost, Georg and Moller), there were no such cases to be observed; there were also no reports published by the Soviet Union and South Africa. We can only approximate the number of asbestos workers employed in all nations from which the total number of lung cancer cases due to asbestos was compiled. For purposes of comparison, we shall consider this to be a minimum of 40,000.

If we calculate 80 cases of lung cancer on 40,000 living humans over a period of 20 years, we get an incidence of lung cancer of 1:10,000 living humans per year. This is much lower than that of the general population, at least as far as central Europe is concerned. However, even assuming

that half of all lung cancer cases due to asbestos are either not recognized or not published, the resulting 160 cases would mean a rate of 2:10,000 among asbestos workers, a rate which is practically within the normal incidence of bronchopulmonary tumors.

With regards to the mortality rate due to asbestos-induced lung cancer, let us emphasize that the asbestos workers are not necessarily to be placed on the same level as asbestosis patients since the appearance of occupational cancer as it seems is related to the presence of pulmonary asbestosis. The incidental differences between asbestos workers and asbestosis patients are given in the last two columns of Figure 1. Please refer also to the high percentage of asbestosis cases among asbestos workers (Wegelius and others). Saupe even suggested that, even after a 10-year exposure to asbestos dust, every asbestos worker has already undergone asbestosis lung changes so that there is an increased probability of asbestos workers and asbestosis patients developing lung cancer, especially with increased exposure to the dust.

The contradiction between Doll's conclusions based on autopsy statistics and our own observations on the incidence of lung cancer due to asbestos, together with the observation of a fifth such case published in Dresden in 1954, promoted us to undertake new statistical studies on the subject based on a broader source of information.

The last case of lung cancer due to asbestos was that of a 63-year-old male suffering from asbestosis I with an autoptically-detected small-cell carcinoma of the right upper lobe bronchus (Dr. Scheid, Head Physician, Pathological Institute of the Dresden-Friedrichstadt Municipal Hospital).

Given the low degree of asbestos changes, the examiner expressed doubts as to the causal relationship between asbestosis and lung cancer. A similar opinion was also expressed by di Biasi in one case of lung cancer due to asbestos and he therefore decided against publication of this case (see below). We do know that the mortality of asbestos workers due to lung cancer is below that of the general population (Worth) and that we can only speak of an increased risk if there is a definite higher incidence of the disease.

So as to increase the number of cases studied with regards to this question, we worked in collaboration with the Berlin-Lichtenberg Academy of Social Hygiene, Occupational Hygiene and Advanced Medical Teaching, the Occupational Medicine Institute (Director: A. Brandt, M.D.), in addition to the 343 cases of asbestosis compiled in Dresden prior to the year 1954 and those reported prior to 1956 to the Silicosis Statistics Bureau of Dresden (Director: B. Kallabis, M.D.), Jena (Director: W. Ahlendorf, M.D.) and Zwickau (Director: G. Sepke, M.D.) and to the Jena Institute of Occupational Medicine (Director: Dr. W. Ehrhardt, Professor). Out of a total of 517 cases, almost 500 originated from the Dresden asbestos industry. Table 1 gives a breakdown by sex and stages of the disease.

TABLE 1.

Asbestosis stage	0-I	I	II	III	Total
men	48	152	99	21	320
women	33	95	48	16	197
	86	247	147	37	517

Of these 517 cases, 17 active cases of lung tuberculosis equals 3%, 10 cases of silicosis and one case of talcosis were diagnosed in vivo (compare this to Jacob and Bohlig); 63 patients were reported as deceased or missing prior to the end of 1956; 11 cases were autopsied and five were found to be suffering from lung cancer due to asbestos. The incidence of lung cancer due to asbestos calculated purely on autopsy statistics was almost 50% which was considerably higher than that quoted by Doll.

As previously pointed out by Jacob and Bohlig on this subject, the autopsy statistics were not performed on random cases. Doll's 105 autopsy cases were also more or less classified by the coroner who ordered that an autopsy be performed "when there may be a question of asbestosis being a contributory cause of death."

For this reason, the percentage figures calculated based on the autopsy statistics (Behrens, Doll, Walz) cannot be considered as accurate mortality figures (Fischer); the only comparable factor remains the incidence based on an equal number of living humans of corresponding ages. Such statistics, however, do not appear to be available in any country at this time.

It is difficult to evaluate the normal incidence of lung cancer of a population group corresponding to that of the asbestos workers. Due to the fact that children and teenagers must be excluded plus the fact that a certain latency period must be taken into consideration and the fact that the average age of 340 first observations of asbestosis was above 50 (Jacob and Bohlig), the incidence must be somewhere between

the middle age of the general population and the 50-79 age group, with its magnitude also depending on the sex breakdown of the asbestos workers.

If we now for comparative purposes compare our own five cases of lung cancer due to asbestos observed among 500 living persons suffering from asbestosis and beyond 60 years of age over a period of 20 years to 10,000 living persons of the general population and the same age group, we get as previously quoted by Schinz a lung cancer expectancy of 6.3 cases per year. If we apply this figure to all of Germany with an approximate total of 4000 asbestos workers as calculated in 1954--figure which is more likely to be low than high--we can consider that there were at least 17 definite cases of lung cancer due to asbestos.*

To these 17 cases we can add Leicher's particularly interesting peritoneal tumor with roentgenologically-detected asbestos content which somewhat differs from the other cases as well as one unpublished case of asbestos-induced lung cancer observed by Bohme in Bochum and confirmed by di Biasi during the autopsy (45-year-old, asbestosis II-III, small-cell solid carcinoma of the left lower lobe; report written in 1957), so that a total of 19 cases of lung cancer due to asbestos were published in Germany.

*Before 1958, more recent statistics for Germany were quoted by Jacob and Bohlig; see Berlin Congress on Cancer in Germany, March 12-14, 1959; report under press.

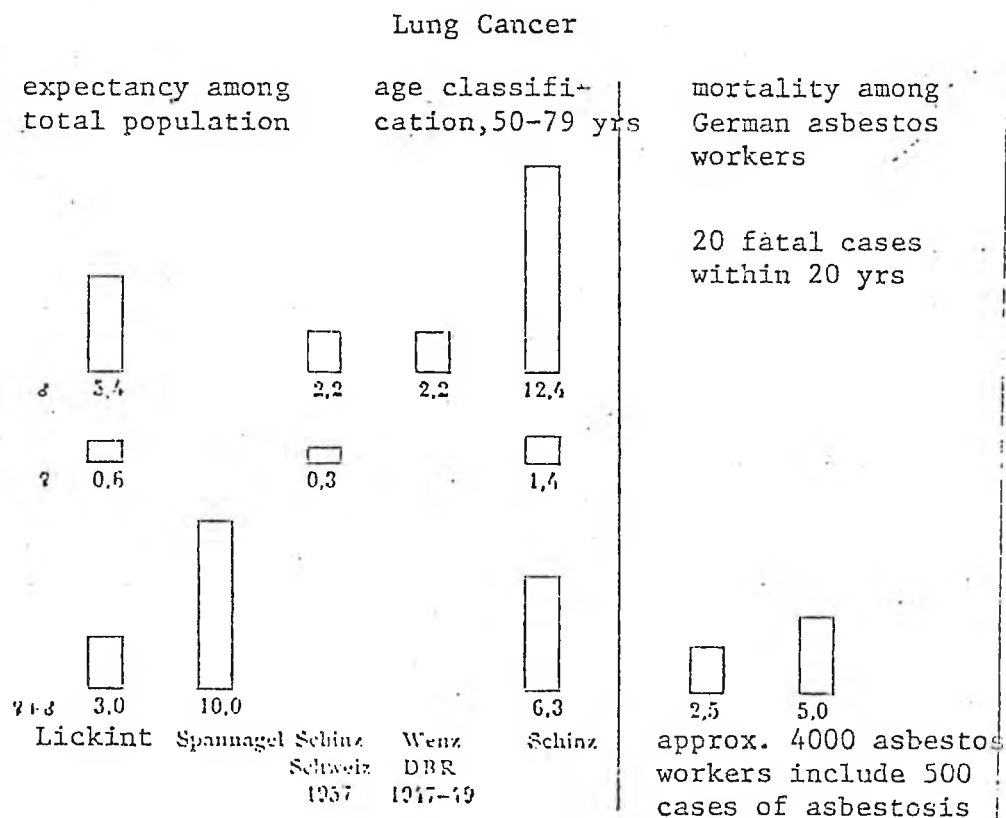
Of course the incidence of lung cancer among the general population is given different interpretations by different authors. Two of us (Jacob and Bohlig) covered this question in more detail in a previous publication. Comparative figures are given in Table 1: with an expectancy such as that quoted by Lickint for instance, 24 asbestos workers out of 4000 would have to have contracted lung cancer over a period of 20 years if the incidence of lung cancer among asbestos workers were similar to that of the general population. The number of cases actually observed would therefore be below the general lung cancer expectancy for higher age groups (as quoted by Schinz for example).

The mortality proportions calculated based on 10,000 living persons are again summarized in Figures 1 and 2 with special emphasis on the difference between the general population and the expected incidence of lung cancer among asbestos workers or persons suffering from asbestosis.

A worldwide survey (based on the literature available) shows similar proportions:

80 published and 80 unpublished cases (see above) equals 160 asbestos-induced lung cancer cases over a period of 20 years among 40,000 asbestos workers of the higher age classes; this is still far below the lung cancer incidence quoted by Schinz, i.e. 240 cases of lung cancer among 40,000 persons over a period of 20 years.

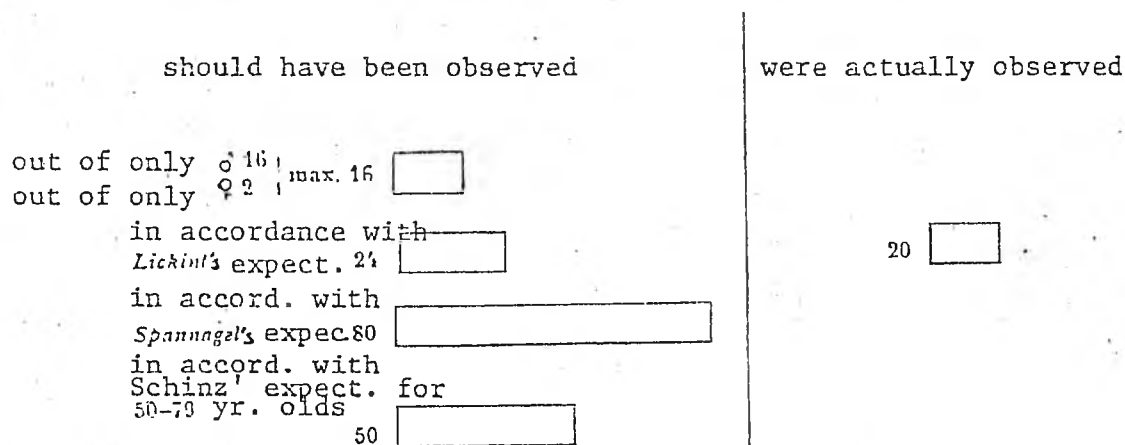
FIGURE 1. (Number of asbestos-induced lung cancer cases--rounded off to the nearest decimal.)



Number of cases per year per 10,000 living persons.

The fact that the proportions are somewhat different for the female asbestos workers had already been suggested by Jacob and Bohlig; as yet no new information has been obtained on this subject and it would appear that the lack of additional extrapulmonary carcinoma would further emphasize the possibility of a sexually different breakdown of asbestos-induced lung cancer related to Peller's "inverse association." The author was unfortunately unable to obtain sufficient from the industry about the general sexual breakdown of their asbestos workers over the past decade so that the proportions quoted below are not necessarily 100% accurate.

FIGURE 2. Number of cases with the same lung cancer expectancy as that of the entire population over a 20-year period (up to 1956) among approximately 4000 German asbestos workers.



The suggestion made in 1954 (Jacob and Bohlig) that not all cases of lung cancer due to asbestos were diagnosed or reported and that the mortality rate due to said disease could therefore not be estimated accurately was brought up again by the authors with regards to the fifth Dresden case. In collaboration with the regional authorities responsible for tumor control in the Dresden area (B. Kallabis, M.D.) and Gera (W. Dalicho, M.D.) and in all regions where workers are employed in asbestos treatment plants, all occupational histories of bronchial carcinoma cases compiled by the regional tumor control centers between the years 1952 and 1956 were analyzed. This showed that out of 1013 lung cancer cases from seven different regions, a total of 22 had been previously exposed to asbestos dust while employed as asbestos workers. Each case was studied individually with regards to the different theories suggested. Subsequent research and collaboration with the plants and the remaining

employees as well as a comparison with our list of asbestosis patients revealed only three cases with actual previous exposure to asbestos dust. Of these, two cases were autopsied but no asbestos could be found in either case. In the third case, there is an entire series of lung X-rays to show that there are no roentgenological signs to indicate the presence of asbestosis here either; this does not mean that there could not be pathological and anatomical asbestosis changes present. Still, even if all three cases had shown evidence of asbestosis-lung cancer, this would not significantly raise the incidence of the disease among asbestos workers as compared to the entire population (see above). For instance, according to the ten-fold increase in the lung cancer risks among asbestos workers as suggested by Doll, only approximately 50 cases of asbestosis-lung cancer could be expected among the cases studied here. Due to the large quantity of material on occupational lung diseases obtained from the Silicosis Statistics Bureau and the intensity with which the author studied each death and cause of death with the assistance of the competent regional tuberculosis control centers as well as numerous clinics and institutes, it is impossible that so many cases of lung cancer due to asbestos could have been overlooked.

Particularly as far as the Dresden proportions are concerned, let us emphasize the fact that overlooking earlier cases of lung cancer due to asbestos among asbestos workers is very unlikely to have taken place (Jacob and Bohlig). The Dresden asbestos industry which was developed over the past decade and continued to develop until 1910 (Dr. Brehmer, Engineer, Cosid Works, Coswig) was not controlled with

regards to occupational hazards during the first decade of its existence due to the lack of knowledge about the correlation between asbestos inhalation and the development of lung diseases. However, even after that, no case of asbestos-induced lung cancer was observed in any of the two pathological institutes of the main Dresden hospitals up to the year 1954 (Grosse, Geipel). On the other hand, serial examinations performed on asbestos workers of the Dresden region by Saupe in collaboration with earlier occupational medical services of the Saxon region (Dr. A. Brandt) date back a long time and, in the institute founded by him, the new radiation clinic of the Dresden Medical Academy (Director: H. Fritz, M.D.) have performed several year-long series of observations of asbestosis patients which are also discussed here.

However, to also include cases from plants where asbestosis had previously been treated or cases which were not reported to the above mentioned silicosis statistics centers, five additional plants of the German Democratic Republic were also included. All plants reported being unaware of any of their previous employees having developed lung cancer. The authors take this opportunity to thank the safety inspection service of the Cosid Works in Coswig near Dresden for the addresses of these plants.

As a result of the authors' intensive retrospective trace of lung cancer cases due to asbestos, it should be noted that occupational cancer is not more frequently observed among the groups of asbestos workers examined than lung cancer among the general population. The discrepancy between these results and the incidence quoted by Doll is not easily explained. There are numerous statistics in England where these are

carefully compiled (Knox). During discussions with Merewether and Knox which took place at the 12th International Congress on Occupational Medicine held in Helsinki in 1957, the English suggested that the asbestosis patients in Germany might be dying so rapidly of lung fibrosis that they never developed lung cancer. This could possibly be true for the time prior to Saupe's studies but could definitely not apply after 1945. Knox reported that hardly any case of asbestos-induced lung cancer had been observed in England since the introduction of dust control devices (Merewether) in the mid-thirties. The authors attach great importance to this fact since it constitutes evidence of Peller's inverse association: in all civilized countries, there was less lung cancer to be observed in the population at that time than nowadays (literature by Lickint); the asbestosis-inducing toxins at that time did not overlap with injuries responsible for the increased incidence of lung cancer. This also applies to all asbestosis and asbestosis-lung cancer statistics of all cases studied as well as the incidence of all other malignant tumors such as stated by Jacob and Bohlig.

However, not only statistics led to the recognition of asbestos-induced lung cancer as an occupational disease in Germany. On the contrary, lung cancer due to asbestos is characterized by several factors relating to the average age, the duration of exposure to the dust, the latency period, the localization, the person's sex as well as histological particularities (Nordmann and Sorge, Wedler, Linzbach and Wedler, Welz, etc.). With regards to these criteria, Jacob and Bohlig in 1954 came to the conclusion that at least part of these characteristics no longer applied.

The statements made concerning 31 cases studied at that time should now be reviewed based on a larger number of cases. The number of lung cancer cases due to asbestos has now increased to 23 (equals 21 males and 2 females: Doll 15, Cartier 5, Rombola 1, di Biasi 1, one case of our own). Unfortunately, the authors were unable to obtain information on some criteria concerning some lung cancer cases due to asbestos reported to the statistics centers by Isselbacher et al., Stoll et al., and some such cases autopsied by Doll so that no evaluation can be made here. Doll and Cartier also did not provide any information as to the localization of the asbestos-induced lung cancer nor on the latency period. The relatively long periods of exposure to the dust which they quoted only allowed limited conclusions to be drawn.

With the larger number of cases now, the male-female sexual breakdown has changed from a ratio of 2.5:1 in 1954 to 4:1. This still means a definite difference with regards to the known sexual ratio for lung cancer which is approximately 1:10 (Lickint et al.).

The average age is 54 years, i.e. 55.7 for males and 46.1 for females. The percentage age breakdown curve (Fig. 3) for asbestos lung cancer now resembles that of lung cancer but shows that the males now contract the disease at a younger age.

There is no new information available on the duration of exposure to the dust. Extreme durations can vary between 19 months and 42 years but the majority is usually about 20-30 years.

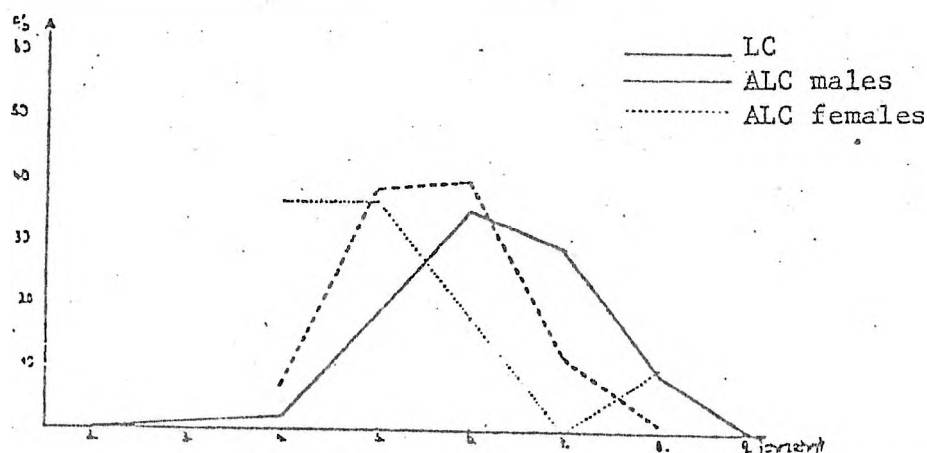
The average latency period of 22.6 years has also remained within the normal limits of cancer expectancy (K.H. Bauer, Lickint) and therefore does not count as a characteristic criterion of asbestos lung cancer.

One point which should not be overlooked is the fact that the patient's smoking habits have never been taken into consideration during the anamnestic evaluation of asbestos workers, asbestosis patients or persons suffering from asbestos lung cancer. Breslow considered undertaking such studies among American asbestos workers. We feel that such studies would also be warranted in England and Germany.

There are many different views with regards to the genesis of asbestosis and asbestos lung cancer. Those who are in support of a purely mechanical mode of development (see above) reject the idea of the toxicity varying with the different types of asbestos (Smith, Brehmer, Brandt). Perhaps the incidence of asbestos lung cancer in several countries could be explained by the asbestos types and treatment processes used. Beger's theory concerning the harmful effect of the freed silicic acid only receives marginal reference. In addition to a mechanical origin, however, Noro and others also consider the possibility of there being additional harmful momenta. On this point, Bohlig and Jacob refer to Leicher's peritoneal tumor which, in fact, showed no clear histological signs of a malignancy and for which a causal correlation with asbestos was only roentgenographically determined, without the detection of any asbestos particles. Knox and Beattie also reject the theory of a mechanical mode of development of asbestosis and consider an as yet undefined fibrogenic agent responsible for the occupational injuries incurred.

Again, we ask you to refer to the animal experimentation performed by Druckreys and Schmahls as well as Nothdurfts on the mechanical development of cancer and the lack of cancer observations in pseudo-asbestos particles of glass, talcum (Erhardt, Ruttner) and the like.

FIGURE 3. Mortality curve for males and females suffering from asbestos lung cancer (ALC) as compared to bronchial carcinoma (BC) of non-occupational origin.



As for the localization of asbestos lung cancer, the number of tumors in the lower lobes is noticeably high (73%). This figure disagrees with all major statistics on lung cancer (Salzer and others, Schinz, Walther, Grosse) and thus would seem to indicate a particular characteristic of asbestos lung cancer.

Although asbestosis itself does more or less conform from a histological point of view (di Biasi, Noro, Wood, Elman, Beintker), Nordmann considers squamous cell carcinoma as characteristic of asbestos lung

cancer. If we overlook the problems involved in the fine tissue differentiation (Fischer) and simply separate the mature forms of cancer from the immature forms, we find based on 45 cases of asbestos lung cancer that the mature forms exceed the expectancy with 73.4% (equals 28 squamous cell carcinomas, two squamous cell carcinomas with transition to adenocarcinoma, three adenocarcinomas). The immature forms can be broken down into seven small-cell carcinomas, two anaplastic and one polymorphous cell carcinoma. There was only one case of scirrhus carcinoma. Eight out of ten females with asbestos lung carcinoma were found to have squamous cell carcinoma. Moreover, a publication by Hueper shows that there are several occupational toxins which could promote lung cancer either by themselves or in groups, but that there cannot be a specific occupational histology of bronchial carcinoma.

Still, in addition to the histological characteristics of asbestos lung cancer, there is a disproportionately high number of serosa tumors to be observed. Among the 53 cases of asbestos lung cancer under study, we found 45 cases of carcinoma, one mediastinal lymphosarcoma (!) and seven serosa tumors. This gives a figure of 13.2% whereas, for instance, Walther's autopsy statistics for Zurich show 4% pleural tumors.

There are also no reports concerning a multicentric development of asbestos lung cancer to be found in the more recent publications.

To summarize, we can say, based on the larger number of cases studied, that the characteristics previously observed with asbestos lung cancer no longer apply or are now only partly valid. Certain sex-related differences with regards to the incidence and age, the localization which is primarily

in the lower lobes, the relatively high proportion of mature forms of cancer and the high number of serosa tumors are not necessarily indicative of lung cancer of occupational origin.

We should finally take a stand and mention the fact that, based on the number of known cases in Germany, there can be no question of an increased incidence of lung cancer among asbestos workers. However, the causal correlation is evidenced by the primary seat of asbestos lung cancer which is generally localized in a lower lobe, the female asbestos worker mortality rate due to asbestos lung cancer which is similar to that of males, and histological factors to a certain degree. The removal of asbestos lung cancer from the list of occupational injuries subject to compensation would therefore not be justified. Further animal experimentation and statistical studies should be undertaken in both parts of Germany to clarify this question.

SUMMARY

Over a period of 20 years, five cases of lung cancer in conjunction with lung asbestosis were observed among 517 asbestosis patients of the Saxon and Thuringen asbestos industries. For the same period of time, the literature reports 19 cases of asbestos tumors for all of Germany and 80 for the entire world. A comparison with the lung cancer expectancy for the general population shows that the risk of asbestos workers and asbestosis patients contracting lung cancer is hardly any higher than that of the general population. Moreover, there are as many female asbestos workers contracting the disease as males. The mortality curve for asbestos lung

cancer shows a peak which is possibly somewhat lower than that of bronchial carcinoma of non-occupational origin. Mature forms of cancer and serosa tumors are frequently observed; more evident is the localization of the primary seat in a lower lobe due to asbestos lung cancer.

The clarification of unanswered questions will require further animal experimentation, a survey of the smoking habits of persons exposed to asbestos dust and exact statistical studies to be performed in all major asbestos centers of the industry.

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