Fiber Levels and Disease in Workers from a Factory Predominantly Using Amosite

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The Cape Boards Plant at Uxbridge produced insulation board containing amosite asbestos between 1947 and 1973 with only small amounts of chrysotile. After 1973 only amosite was used. In this study we examined lung samples from 48 workers who had been employed at the plant and who had come to autopsy. The study investigated the fiber levels against the lung pathology including amount of interstitial fibrosis and numbers of ferruginous bodies. The degree of interstitial fibrosis and number of asbestos bodies were graded and the tissues were analyzed by transmission electron microscopy and energy dispersive X-ray analysis and the fibers counted and typed. The 48 cases included 5 mesotheliomas and 14 lung cancers. The mineral analysis results were dominated by the amosite fiber levels. The amounts of chrysotile were relatively small. There were higher levels in lung cancer cases than mesotheliomas and higher levels in mesothelioma cases than those who had died from nonasbestos related diseases. Analysis of the lung tissues showed a consistent pattern of high amosite levels, which confirms the impression that amosite was the predominant form of asbestos used and also indicates that the factory had been a very dusty one. — Environ Health Perspect 102 (Suppl 5):261–263 (1994).

Key words: asbestos, amosite, chrysotile, fibrosis, asbestosis, lung cancer, mesothelioma

Introduction

The Cape Boards Plant at Uxbridge has produced insulation board containing predominantly amosite since 1947 but with usage of small amounts of very short chrysotile fiber (grades 6 or 7). Since 1973 amosite has been the only type of asbestos used. In 1981 Acheson et al. reported five mesotheliomas (four pleural and one peritoneal), four of which they associated with work at the factory (*1*). In a further study they described the mortality experience, up to the end of 1980, of 5,969 men employed at the same factory and found a doubling of the risk of lung cancer, five mesotheliomas and nine deaths from asbestosis (*2*). However, epidemiological studies of workers from plants that were considered to have been exposed to only one type of asbestos fiber have not always been accurate. For example, mineralogical examination of the lung tissues of autopsied workers from the Rochdale textile plant who were initially thought to be mainly exposed to chrysotile asbestos (*3*) surprisingly showed substantial amounts of crocidolite (*4*). It later became apparent that in fact significant amounts of crocidolite had been used at that plant.

We obtained lung tissues from workers at the Uxbridge plant who had come to autopsy and examined the pathological changes in relation to mineral content; no similar study of a predominantly amosite facility has been reported. Also, the tissue fiber studies would indicate the relative amounts of the different types of fiber used.

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Materials and Methods

Pathology

Pathologists and coroners provided 143 paraffin blocks of lung tissue from 48 subjects. From one additional subject, histological sections only were available. Histological sections were cut and stained from each block and the degree of fibrosis and ferruginous bodies were graded numerically as follows (*5*):

Fibrosis

0. Absent
1. Slight degree of reticulin or collagen accumulation around respiratory bronchioles.
2. Fibrosis around respiratory bronchioles extending into adjacent alveolar ducts, atria and alveoli but not extending to adjacent respiratory bronchioles.
3. Fibrosis linking adjacent respiratory bronchioles.
4. Widespread fibrosis with or without honeycombing.

In some cases the degree of fibrosis was not assessed because adequate samples of lung tissue had not been taken away from tumor.

Ferruginous Bodies

0. Absent
1. Average of one or less per section.
2. More than one per section but requiring careful search to find them.
3. Easily found but forming only occasional clusters.
4. Easily found with numerous clusters.

In addition, any tumor present was classified and additional histochemical and immunohistochemical procedures performed, particularly periodic acid-shift procedure (PAS) with and without diastase, cytokeratin, and carcinoembryonic antigen (CEA).

Mineralogy

Appropriate tissue for mineral analysis was available for 43 cases only. The paraffin wax was removed from the tissue blocks by xylene and the tissue was digested in 40% potassium hydroxide, washed, then ashed at 350°C for 3 hr in an oxygen atmosphere. The final extract was suspended in distilled water and aliquots of known volume were filtered onto Nucleopore filters. These were carbon coated, the filters were dissolved in chloroform, and the carbon films were mounted onto gold electron microscope support grids for transmission electron microscopy. Between 100 and 200 fibers were counted and analyzed by energy dispersive X-ray analysis for each case (*6*).

Results

The entire population consisted of 49 subjects, but several had missing values. The subjects included five pleural mesotheliomas and 14 lung cancers. The mineral analysis results (given in millions of fibers per g of dried lung tissue) were dominated by the amosite fiber levels (Table 1). All results for total fiber count and amphiboles followed the same pattern, so only amosite results will be presented in the later tables.

Table 1. Mean fiber counts ($\times 10^6$) for 43 subjects.

Variable	Mean	Median	SD	Number with zero levels	Maximum
Amosite	784.9	106.3	1603.9	2	7852.9
Crocidolite	22.5	0.1	72.7	19	397.3
Chrysotile	12.1	1.1	24.3	14	135.5
Mullite	8.6	3.9	14.2	9	309.3
Anthophyllite	0.7	0	4.8	42	31.6

Table 2. Amosite and chrysotile fiber levels ($\times 10^6$) by grade of fibrosis.

	Amosite		Chrysotile		
Grade	Mean	SD	Mean	SD	Cases
0.0	3.9	4.2	3.4	4.2	3
0.5	5.1	5.6	.3	.4	5
1.0	321.3	343.6	24.8	27.4	4
1.5	469.9	821.5	4.7	8.6	6
2.0	671.5	510.6	9.6	11.4	3
2.5	1656.6	2342.3	.0	.0	2
3.0	194.7	175.2	26.6	16.8	4
4.0	1916.3	2693.1	19.2	41.1	11

Table 3. Amosite and chrysotile levels by grade of ferruginous bodies.

	Amosite		Chrysotile		
Grade	Mean	SD	Mean	SD	Cases
0.0	1.4	2.7	1.5	2.4	10
1.0	28.0	19.2	1.7	1.1	3
2.0	272.9	436.3	33.5	57.6	5
2.5	395.3	656.5	0.1	0.2	3
3.0	464.5	650.2	24.4	17.9	9
4.0	1951.9	2497.4	8.7	16.4	13

Table 4. Fiber count ($\times 10^6$) by type of pathology.

	Total		Amosite		
Pathology	Mean	SD	Mean	SD	Cases
Mesothelioma	1035.0	1038.9	1000.7	1012.9	5
Lung cancer	1483.3	2567.9	1433.8	2590.1	14
Other	358.0	489.9	296.9	463.4	24

Wilcoxon rank tests for unpaired data

Mean rank	Cases
11.20	5 Mesotheliomas
9.57	14 Lung cancers
	2-tailed $p = 0.5786$
	1-tailed $p = 0.2893$

Mean rank	Cases
22.64	14 Lung cancers
17.67	24 Others
	2-tailed $p = 0.1830$
	1-tailed $p = 0.0915$

Mean rank	Cases
13.79	24 Others
20.80	5 Mesotheliomas
	2-tailed $p = 0.0941$
	2-tailed $p = 0.0471$

Chrysotile was analyzed separately but due to the low levels did not reveal any results of significance. Three of the 49 cases, all lung cancers, had very high counts and could be considered as outliers—they had amosite counts of 6476, 7853, and 3313 (millions per g dried tissue) and were each graded 4 for fibrosis and ferruginous bodies. Where appropriate, analyses were performed both with and without these cases. There was a definite positive relationship between the amosite levels and grades of fibrosis and asbestos bodies. (Tables 2, 3).

Conclusions were unaffected by the inclusion or exclusion of the three outliers. Regressions of grades on amosite, chrysotile, and time of exposure verified the significant relationship between amosite levels and grades but indicated that time of exposure affected the grades to a lesser extent. There was no evidence that the levels of chrysotile affected grades but the amounts of chrysotile were small (Tables 2, 3). There were higher levels of amosite fibers in lung cancer cases than in mesothelioma cases, and higher levels in mesothelioma cases than in the other cases (Table 4). Nonparametric (Wilcoxon Rank Sum) tests on these data and standard (parametric) *t*-tests on the log data were performed with similar results and levels of significance for both. Only the results of the nonparametric tests are given in Table 4. The comparison of mesothelioma with "other" cases is significant at the 10% level for a 2-tailed test and at the 5% level for a 1-tailed rest. There is no significant difference between the mesothelioma and lung cancer values. The major difficulty with the data is the lung cancer group, which contains three cases whose very high counts make it difficult to draw any firm conclusions in comparing them with the other two categories. The main feature that distinguishes the lung cancer group from the other two groups is that it contains the three very high counts. The positive relationship of grades to amosite fiber levels was much the same for mesothelioma and lung cancer cases; but there were more lung cancer cases than mesothelioma cases for the higher grades of fibrosis and asbestos bodies.

Discussion

In general, the fiber counts were high in these subjects and similar to those reported in a study of an East London asbestos factory that used crocidolite, amosite and chrysotile (*7*). Measurements of airborne samples in the late 1960s within the Uxbridge plant showed some areas to contain more than 30 fibers/ml but prior to 1964 the counts were probably higher (*2*). These tissue fiber burden results support the suggestion that this was a dusty factory up to the 1960s. The various types of asbestos-related disease were more frequent in the East London factory, where a substantial amount of crocidolite was used. This is in agreement with other studies that have shown a gradient of disease among the fiber types: in descending order crocidolite, amosite, and chrysotile (*8,9*). If the tissue levels found in this study had been crocidolite rather than amosite, one would have expected a much greater prevalence of mesotheliomas.

The results of the tissue fiber burdens tests were dominated by the amosite, which corroborates information given by the factory that amosite was the fiber predominantly used. Eleven subjects, including one of the mesothelioma cases, had substantial amounts of crocidolite present but the exposure could have occurred outside this factory.

The results also showed that increasing fibrosis was related to increasing amosite, but not chrysotile levels. This supports the findings of other studies, which have shown better correlations between fibrosis and amphibole than with chrysotile tissue levels (*7,10*). Our results are not completely consistent in that the grade 3 fibrosis subjects showed a lower mean amosite level than grade 1 to 2.5 subjects. This probably is explainable by sampling error. Unfortunately, due to the retrospective nature of the study, the geographical spread of the specimens, and the involvement of several pathologists, a systematic sampling procedure of the lung specimens could not be employed. Nevertheless there seems little doubt that, in this series, there was a correlation between fibrosis and tissue fiber levels. There were also correlations of both these factors with the grading of ferruginous bodies. In fact, the appearances of the ferruginous bodies were typical of asbestos bodies. Generally amosite produces proportionately more asbestos bodies than crocidolite, which in turn produces proportionately more than chrysotile (*11*). In terms of assessing asbestosis, the light microscopic grading of asbestos bodies and fibrosis appears reasonably accurate and useful where the predominant exposure has been to amosite.

The fiber counts were very high in the mesothelioma cases. Only three of the five cases had tissue suitable for the assessment of fibrosis, and these showed moderate to severe asbestosis. The fiber counts were higher in those with asbestos-related disease than in those without.

Conclusion

This is a brief report of a pathological and mineralogical study of lung tissues from subjects who had worked at a factory that predominantly utilized amosite. To the best of our knowledge, this is the first mineralogical and pathological study of such a group.

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