PLAINTIFF'S EXHIBIT BASF-7

Effect of Asbestos Dust Inhalation on Lung Function

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THE NAME asbestos is used to cover a group of fibrous mineral silicates. Those of commercial importance include chrysotile, a hydrated magnesium silicate; amosite, a magnesium iron silicate; and crocidolite, an iron sodium silicate. Prolonged inhalation of significant amounts of asbestos dust over an extended period of time can produce in certain individuals a respiratory disorder known as asbestosis. It is characterized primarily by cough, dyspnea, basal crepitations, and reticulonodular shadowing of the chest roentgenogram. Clubbing and cyanosis are usually seen in the more advanced stage of this disorder. Chronic bronchitis and emphysema are associated with this disease, the emphysema being more of a localized than a diffuse obstructive type. Cor pulmonale is the major complication and the usual cause of death from this disease. There is an increased incidence of lung carcinoma associated with asbestosis. The most consistent pathological change is a dense fibrosis containing macrophages with absorbed dust particles which in many areas obliterates the pulmonary architecture. A pattern of endarteritis with intimal hyperplasia consistent with pulmonary hypertension and bronchiolectasia are associated major findings. Rather striking is the presence of elongated, terminally clubbed bodies, both segmented and unsegmented, in the respiratory bronchioles or imbedded in the fibrous tissue or both. The pleura often shows dense fibrotic thickening and not infrequently there are calcified pleural plaques over the pleural surfaces. The clinical and pathological features are indicative of a pronounced dysfunction of the respiratory mechanism. This has been confirmed by studies of pulmonary function which have shown a disturbance in both ventilatory function and diffusion capacity.[1-7] Most studies to date have been confined to individuals who, having sustained exposure to asbestos dust, showed positive radiologic evidence on the chest roentgenogram. It is the purpose of this report to present data on the clinical and physiological findings in individuals who had sustained exposure to asbestos dust of 14 years or more irrespective of the radiologic findings on the chest roentgenogram.

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Material and Methods

The study group comprised 56 asbestos workers. They were selected on the basis of having had an exposure to asbestos dust, as asbestos insulators, for 14 years or more and no previous occupational dust exposure. Each worker underwent a detailed medical, social, and occupational history, a clinical examination, a 12-lead electrocardiogram, a chest roentgenogram, and a battery of pulmonary function tests. The pulmonary function tests included vital capacity (VC), one-second vital capacity (VC_1), residual volume (RV), total lung capacity (TLC), and pulmonary diffusion capacity for carbon monoxide ($D_{L_{CO}}$). The vital capacity and one-second vital capacity were measured by a Krogh spirometer and the volume changes of the spirometer were electrically recorded on a Texas

TABLE 1.—*Clinical and Physiological Findings in Control and Asbestos Worker Groups*

	Controls		Asbestos Workers		P
No. in Group	50		56		
Age (yr)					
Mean	49.2		49.4		NS
Range	35-63		32-77		
Clinical	No.	%	No.	%	
Cough	3	6.0	18	32.1	<0.01
Dyspnea	5	10.0	9	16.1	NS
Lung crepitations	0	0.0	11	19.6	<0.01
Clubbing	0	0.0	8	14.3	<0.01
Physiologic *					
VC (% predicted)	101.1±1.9		81.3±2.1		<0.01
VC_1 (% VC)	76.7±0.9		77.0±1.3		NS
RV (% predicted)	90.1±2.7		96.7±3.7		NS
TLC (% predicted)	88.0±1.6		82.0±1.7		<0.01
RV/TLC (% predicted)	88.6±2.9		111.6±2.0		<0.01
$D_{L_{co}}$ (cc/mm Hg/min)	31.6±1.0		24.0±1.0 †		<0.01

* Expressed as mean values ± standard errors

† Based on 48 asbestos workers

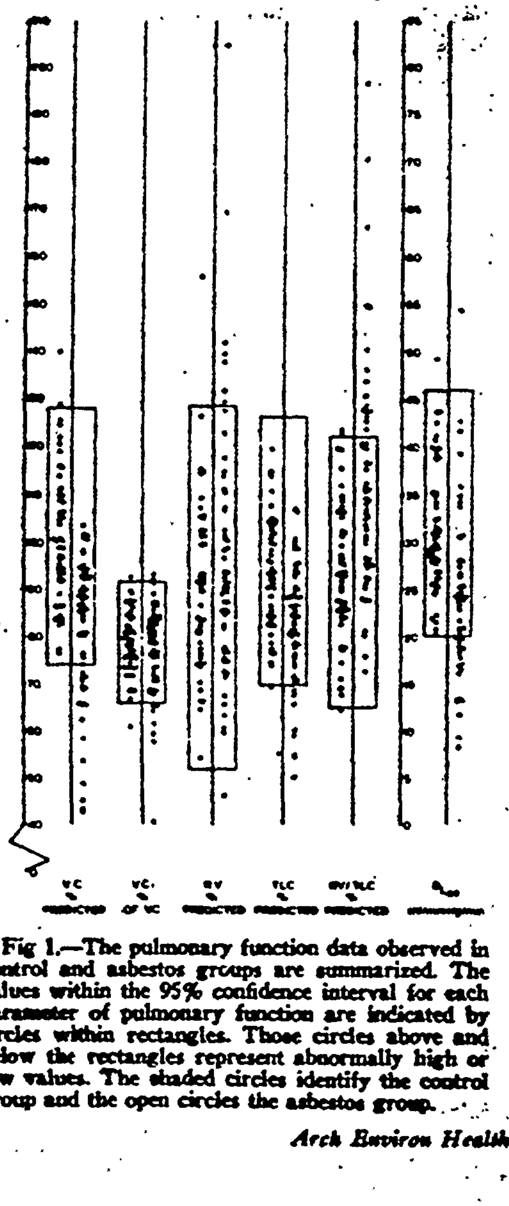

Fig 1.—The pulmonary function data observed in control and asbestos groups are summarized. The values within the 95% confidence interval for each parameter of pulmonary function are indicated by circles within rectangles. Those circles above and below the rectangles represent abnormally high or low values. The shaded circles identify the control group and the open circles the asbestos group.

rectiriter recorder. The residual volume was determined by a nitrogen dilution method using the closed circuit technique as recommended by Wright and Gilford.[3] All lung measurements were determined at ambient temperature and pressure, saturated (ATPS). The values for residual volume were corrected for the dead space of the breathing tube and the phase of expiration in which the subject was connected to the spirometer. The $D_{L_{co}}$ was determined at rest by a single breath technique described by Ogilvie et al.[4] Predicted values for vital capacity, residual volume, total lung capacity, and ratio of residual volume to total lung capacity were calculated on the basis of the best regression equations of Needham et al.[4] For $D_{L_{co}}$ the observed readings were used. The control group was comprised of 50 men whose occupations varied and who had no prior occupational dust exposure. The 95% confidence intervals for all the lung parameters were based on the data obtained from the control group.

Findings

The predominant clinical and physiologic findings of the asbestos workers and controls are given in Table 1.

Clinical.—The asbestos workers ranged in age from 32 to 77 years, with a mean of 49.4 years. The mean age of the controls was 49.2 with a range of 35 to 63 years. The mean ages of two groups were not significantly different. Eighteen of the asbestos workers had a chronic cough for an average duration of 9.5 years. In 12 of the 18 the cough was productive. Three of the controls had a chronic cough, the average duration being 5.3 years. In all the cough was productive. Nine of the asbestos workers had

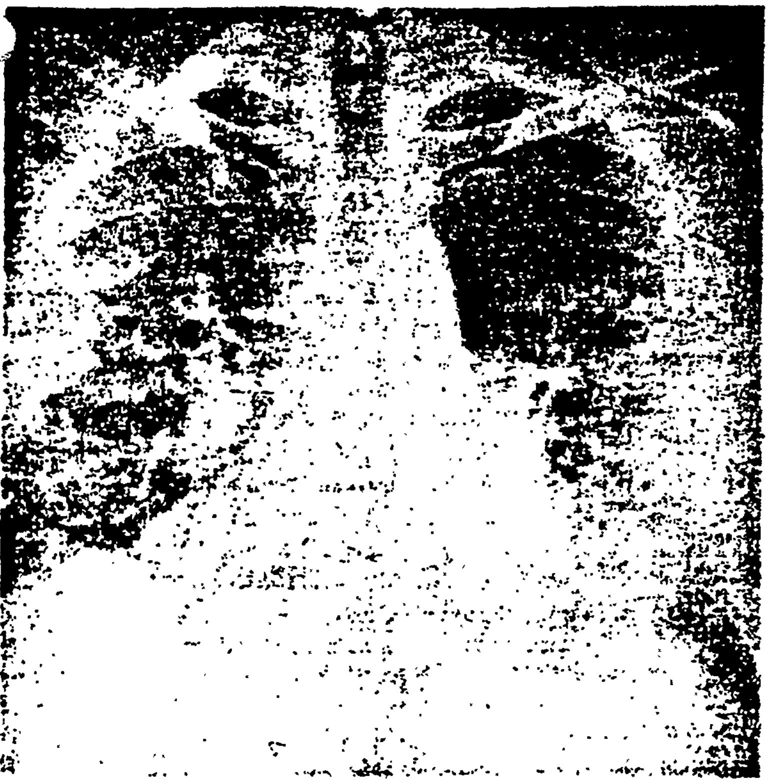

Fig 2.—A 47-year-old asbestos insulator with 22 years of asbestos dust exposure, showing diffuse infiltration involving more than 50% of the lung area. Both cardiac borders are obscured.

spnea which in five was minimal, in three moderate, and in one moderately severe. There were five individuals in the control group who had dyspnea and in all the dyspnea was of minimal degree. Lung crepitations were present in 11 of the asbestos workers and in none of the controls. Eight asbestos workers showed clubbing; the controls showed none. The comparative incidences of cough, lung crepitations, and clubbing in the control and asbestos groups were statistically significant. A positive smoking history was obtained in 40 of the asbestos workers and in 21 of the controls. The comparative incidence of smoking for the two groups was statistically significant. The criterion for a positive history of smoking was 20 cigarettes a day for a minimum of five years.

Roentgenographic.—Twenty-one of the 56 asbestos workers had positive radiologic findings of pulmonary infiltration. In eight of the workers, the infiltration was of grade 1, in nine, of grade 2 and in four, of grade 3. The criteria for grade 1 was a reticulated earance in the lower lung fields; for grade 2, a reticulonodular infiltration involving approximately 50% of the total lung area; and for grade 3, a more diffuse reticulonodular infiltration involving more than 50% of the total lung area. In addition to the pulmonary infiltration, there was also a varying degree of obliteration of the costophrenic sinuses in 16 individuals and/or the cardiac borders in ten. Pleural calcification was observed in five instances. Two individuals showed emphysema which was localized to the left upper lobe in one and the right upper lobe in the other. Cardiac enlargement was found in one individual and was of minimal degree. None of the controls showed any pulmonary infiltration. Five individuals showed cardiac enlargement, all of minimal degree.

Physiologic.—The values within the normal range for each parameter of pulmonary function studies are indicated by the circles within the rectangles shown in Fig 1. Those circles above and below the rectangles lie outside the 95% confidence interval. Low values for vital capacity (less than 74.0% predicted) were found in 17 of the 56 asbestos workers. No individual in the control group had a value less than 74% predicted.

Fig 3.—The lung function data observed in 20 asbestos workers without and 16 with positive radiological findings. The values within the 95% confidence interval for each parameter of pulmonary function are indicated by circles within rectangles. The shaded circles represent those without and the open circles those with positive radiological findings.

The low values in the asbestos group ranged from 42.9 to 72.1% predicted. The one-second vital capacity was less than 65.7% in seven asbestos workers and in one control. In the asbestos group the low values ranged from 40.1 to 65.2. The one low value in the controls was 60.7. Values for residual volume above 128.5% predicted were found in seven asbestos workers and in one individual of the control group. The high values in the former ranged from 129.3 to 204.6% predicted and that in the latter was 156.9% predicted. The values for total lung capacity less than 69.8% predicted were found in eight asbestos workers and in one of the control group. The low values in the asbestos group ranged from 50.3 to 68.9 predicted. The single abnormal value in the control group was 69.4% predicted. The ratio of residual volume to total lung capacity was above 122.2% predicted in 16 of the asbestos group, the high values ranging from 123.7 to 196.6% predicted. Two individuals in the control group had values above 122.2% predicted, namely 122.3 and 123.3% predicted. Eighteen of the asbestos workers had a $D_{L_{CO}}$ less than 20.0 cc/mm Hg/min. No individual in the control group had a value below this. Among the asbestos workers, the low values ranged from 8.3 to 19.9 cc/mm Hg/min. With the exception of the mean residual volume and the one-second vital capacity, the mean values of the other pulmonary function parameters were significantly different between the two groups.

Environmental.—The asbestos dusts to which the asbestos workers were exposed were chrysotile and amosite. The degree to which each individual was exposed was difficult to estimate. However, of the 56 asbestos workers, 28 were exposed between 14 and 19+ years, 9 were exposed between 20 and 24+ years, and 19 were exposed for over 24+ years. The mean duration of exposure for the 56 workers was 24.3 years with a range of 14 to 57 years.

Comment

The data in Table 1 show that the asbestos workers as a group have a greater incidence of abnormal clinical and physiologic findings referable to the respiratory system than does the control group. The clinical picture characterized by cough, dyspnea, lung crepitations, and clubbing, although not diagnostic, is consistent with sustained exposure to asbestos dust. The positive radiologic changes on the chest roentgenogram, characterized by reticulonodular shadowing, obscuration of the cardiac borders and/or costophrenic sinuses (Fig 2) are similar to what has been observed in previous studies of asbestos workers.[3] These changes resemble those found in talcosis.[4] It is noteworthy, as shown in Table 2, that when 16 of the 56 asbestos workers with positive radiological evidence were com-

TABLE 2.—*Clinical and Physiological Findings in Asbestos Workers With and Without Pulmonary Infiltration*

	Without Pulmonary Infiltration		With Pulmonary Infiltration		P
No. in Group	20		16		
Age (yr)					
Mean	49.2		50.4		NS
Range	37-60		39-62		
Exposure (yr)					
Mean	22.6		25.3		NS
Range	18-40		18-38		
Clinical	No.	%	No.	%	
Cough	5	25.0	8	50.0	NS
Dyspnea	2	10.0	4	25.0	NS
Lung crepitations	3	15.0	5	31.3	NS
Clubbing	0	0.0	3	18.8	NS
Physiologic *					
VC (% predicted)	88.2±2.0		70.5±4.4		<0.01
VC_1 (% VC)	76.2±2.3		75.3±2.6		NS
RV (% predicted)	106.0±7.2		95.9±0.6		NS
TLC (% predicted)	89.5±1.7		75.0±3.5		<0.01
RV/TLC (% predicted)	112.5±6.2		122.3±5.3		NS
$D_{L_{CO}}$ (cc/mm Hg/min)	27.2±1.5		20.8±1.9 †		<0.05

* Expressed as mean values ± standard errors
† Based on 15 workers

pared with 20 of similar mean age and range and duration of exposure but having negative radiological findings, there were no significant differences in the clinical findings between the two groups. However, those with positive radiological evidence had a significantly lower mean predicted vital capacity, total lung capacity, and $D_{L_{CO}}$ than those without such evidence. Although the lower values cannot be attributed to differences in duration of dust exposure of those with and without positive radiologic changes, one cannot exclude the possibility that the two groups may have had different degrees of dust exposure. Unfortunately, as has already been mentioned, it was not possible to estimate the degrees of dust exposure for each individual or for the groups as a whole.

Although the mean values of the lung function parameters measured for the group of asbestos workers as a whole fall within the 95% confidence limits for the control group, it can be seen in Fig 1 that an appreciable number of asbestos workers fall outside these limits. This is particularly evident in vital capacity and in diffusion capacity parameters and to a lesser extent in the other parameters. Moreover, the proportion of abnormal lung function readings for VC, VC_1, TLC and $D_{L_{CO}}$ in the group with positive radiological evidence exceeded those in the group with negative radiological findings (Fig 3). The greater proportion of abnormal values for one-second vital capacity in the asbestos group compared with the control and in those with positive radiological findings compared with the negative group can be ascribed to the greater number of smokers in these groups (Fig 1 and 3).

In general, the correlation between the degree of pulmonary function impairment and the clinical and roentgenographic findings was poor for the exposed group as a whole and no consistent correlation could be found between the duration of exposure and lung function impairment in this group. The lack of a good correlation between the degree of pulmonary function impairment and the clinical, roentgenographic, and environmental findings observed in the present study has also been reported by Bader et al.[7] This has also been noted in other pneumoconioses such as a coal workers' pneumoconiosis [8] and anthracosilicosis.[9]

Summary and Conclusions

Pulmonary function tests were performed on 56 workers engaged in asbestos insulation. The mean duration of exposure was 24.3 years with a range of 14 to 57 years. The predominant symptoms were dyspnea (9) and cough (18). Basilar crepitations and clubbing were noted in 11 and 8, respectively. The mean predicted values for the various pulmonary function parameters measured were within the 95% confidence limits of the control group. However, an appreciable number of asbestos workers had values which fell outside these limits. This was particularly evident in the vital capacity and $D_{L_{CO}}$. There were 16 who showed pulmonary infiltration on their chest roentgenograms as compared to 40 without such evidence. Those with positive radiologic findings had a proportionately greated number of abnormal pulmonary function values as compared to those without. In general, the correlation between the degree of pulmonary function impairment and the clinical and radiological findings was poor for the exposed group as a whole and no consistent correlation could be found between the duration of exposure and lung function impairment in this group.

Dr. Emanuel Levin of Maimonides Hospital of Brooklyn and the State University of New York, Downstate Medical Center, Brooklyn, NY reviewed the chest roentgenograms.

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INCREASING USE OF A TEAM APPROACH TO HEALTH CARE

. . . the rise of specialization and the rapid decline in numbers of general practitioners has resulted inevitably in an increasing tendency toward team practice involving the contribution of various specialists. As specialization increases, so does the need for coordination of the team that is essential to care for the patient. The team that requires coordination includes both physicians with a variety of specialties and an ever-increasing number of allied health personnel with competence to perform more routine technical tasks. The physician's knowledge can no longer encompass the details of all procedures performed by other members of the team. These developments require the attending physician to be a "coordinator" or "team leader" of a team that collaborates loosely to meet the needs of the patient.

There is no clear alternative to the organization of the modern practice of medicine as a team effort—and the doctor must be trained specifically to function as leader of the team. Teamwork is mandatory in most activities of the modern world—industry, communications, education—and it should not be impossible in the health sciences. The team leader, if he is to maintain his leadership, must recognize his responsibilities and be prepared to meet them.

The team approach is manifesting itself in the hospital, the clinic, the many kinds of group practices that have come into use in the past half century. There is every likelihood that the team approach to health care will expand in use in decades ahead and that teams will become larger, more comprehensive in the range of skills included, and more complex in structure. This will further advance the institutionalization of health care and it has profound implications for the education of all persons entering medicine and the other health professions and occupations.—Coggeshall, L.T.: Planning for Medical Progress Through Education, A Report Submitted to the Executive Council of the Association of American Medical Colleges, April 1965, p 25.