

Changes on Radiographs of Wives of Workers Exposed to Asbestos¹

Between January and March 1986, 117 wives of insulation workers exposed to asbestos were screened by means of chest radiography, pulmonary function testing, and a detailed questionnaire. The final study group included 93 women over 40 years of age. Eighteen of these (19.4%) demonstrated pleural changes consistent with asbestos exposure, including pleural plaque (98.9%), diaphragm plaque (27.8%), pleural calcification (16.6%), and diffuse pleural thickening (5.5%). In statistical correlation between the groups with normal and abnormal radiographs, the only factor that proved significant was the year of first exposure (the duration of the latent period). Finally, radiographs of the husbands were compared for 17 of the 18 wives with radiographic abnormalities. Fourteen of the husbands (22%) demonstrated more severe radiographic changes than their wives.

Index terms: Asbestosis, 66.773
Pleural diseases, 66.773

Radiology 1987; 164:723-726

EXPOSURE to asbestos fibers has long been recognized as a cause of radiographic and functional abnormalities of the chest. The radiographic changes range from limited pleural plaque formation to complex parenchymal fibrosis and malignancy, and they have been noted for all types of asbestos exposure, including mining, milling, and insulation. Less attention has been given to the household contacts of these asbestos workers, a group with only limited or secondary exposure. Although this at-risk population was originally described in 1960 and 1965, few investigations have centered on it (1, 2). Both of these initial studies concerned the presence of mesothelioma in first environmental contacts and later household contacts. We recently screened 117 wives of pipe coverers and asbestos removers for radiographic, functional, and symptomatic abnormalities.

MATERIALS AND METHODS

From January to March of 1986, 194 insulation workers exposed to asbestos and 117 of their wives were screened in a voluntary program at Northwestern Memorial Hospital in Chicago. The screening program was offered through the local pipe coverers' union and was available to current and retired workers and their wives.

A posteroanterior chest radiograph was obtained for each patient by means of standard techniques (140 kV). Film quality was monitored throughout the program to assure good-quality radiographs. The chest radiograph was rated by a certified "B" reader and graded according to the 1980 International Labor Organization (ILO) classification system. The reader had no knowledge of the patient's length of exposure to asbestos, age, or familial exposure history. A second B reader reviewed some of the radiographs.

The screening program also included pulmonary function testing monitored and administered by the pulmonary medicine department. Forced vital capaci-

ty (FVC) (percent predicted) and forced expiratory volume (FEV₁) (percent predicted) were chosen as indicators of functional status, as set forth by Environmental Protection Agency guidelines. Forced expiratory flow (FEF) (75-25) was also obtained as a more sensitive indicator of small airway disease.

An additional questionnaire was subsequently presented to the wives that participated in the screening program. Specific questions concerned length and amount of cigarette smoking, breathing problems, past diagnoses of heart or pulmonary disease, and known chest radiographic abnormalities. Additional questions pertained to asbestos-exposed husbands, fathers, brothers, or sons, including year of first exposure, years living in the same house, date of retirement, other medical problems, and previous employment. All information obtained from the survey was submitted for statistical analysis by an outside statistician who had no prior knowledge of expected results.

RESULTS

None of the 24 women under 40 years of age demonstrated radiographic abnormalities, and each of them had been exposed for less than 8 years. We therefore chose to exclude this group. Of the 93 women remaining, 18 (19.4%) had radiographic abnormalities consistent with asbestos exposure, as defined by the ILO classification. The radiographic findings are presented in Table 1. Most of the abnormalities were limited to circumscribed plaque formation of width A or B and extent 1 or 2 along the lateral aspect of the chest wall or face on plaque extent 1 or 2 (88.9%) (Fig. 1). Plaques on the diaphragm were seen in six cases (33.3%), and in two cases (11.1%) these were the only evidence of asbestos exposure. Calcification of the chest wall or diaphragm plaques was seen in three cases (16.7%) (Fig. 2). Diffuse pleural thickening was present in only one case (5.5%).

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Table 1
Abnormal Radiographic Findings

Finding	Width			Extent			Total No. of Cases*
	A	B	C	1	2	3	
Circumscribed pleural thickening							
Right chest wall	8	3	0	9	2	0	11/18 (61.1)
Right face on	...	...	...	1	5	2	8/18 (44.4)
Left chest wall	8	4	0	11	1	0	12/18 (66.7)
Left face on	...	...	...	4	3	0	7/18 (38.9)
Diffuse pleural thickening							
Right chest wall	0	0	0	0	0	0	0/18 (0)
Left chest wall	1	0	0	0	1	0	1/18 (5.5)
Pleural calcification							
Right	...	...	...	1	0	0	1/18 (5.5)
Left	...	...	...	2	0	0	2/18 (11.1)

Note.—A, B, C and 1, 2, 3 refer to the ILO classification system. Five subjects (27.8%) had plaque on the right side of the diaphragm, six (33.3%) on the left.
* Percentages in parentheses.

Table 2
Pulmonary Function Test Results

Parameter	Normal Radiographs (n = 75)	Abnormal Radiographs (n = 18)	P
FEV ₁ (% predicted)	99.8 ± 15.4	90.7 ± 14.0	<.028
FVC (% predicted)	101.7 ± 14.0	92.0 ± 13.2	<.011
FEF (75-25) (% predicted)	95.5 ± 29.7	89.4 ± 31.8	<.456

Note.—Values indicate means with standard deviations (SD).



Figures 1, 2. (1) Limited face on calcified pleural plaque (arrows). (2) Extensive plaque in profile and face on (arrows).

There was no evidence of parenchymal opacities or thoracic malignancy.

The pulmonary function tests revealed no significant "functional" impairment in either the group with normal or the group with abnormal radiographs, although there were sta-

tistical differences for the measured parameters (Table 2).

Data from the questionnaires are presented in Tables 3-8. Virtually every woman questioned described her exposure as primarily from shaking and washing her husband's clothes.

Those whose fathers or brothers were asbestos workers also reported similar exposure. None were asbestos workers themselves.

Many of the women were not exposed continually to asbestos because their husbands had changed jobs or retired. Only the year of initial exposure was statistically significant. The 18 women with abnormal radiographs had a mean year of initial exposure of 1952, versus 1958 for the 75 with normal radiographs ($P < .037$). The differences in total years of exposure ($P < .72$), number of family contacts ($P < .89$), and age ($P < .20$) were not statistically significant. The women with normal radiographs showed a statistically greater smoking history than those with plaque formation ($P < .024$).

Finally, the radiographs of 17 of the 18 women with positive findings were compared with those of their husbands. (One of the husbands died of heart disease 1 year before the study.) Fourteen of the husbands had pleural involvement more severe than that of their wives. Six of these men also had concurrent parenchymal abnormalities consistent with asbestos exposure. Three husbands had normal radiographs, and their wives all demonstrated only mild radiographic abnormalities, with chest wall plaques of extent 1 ($n = 2$) or 2 ($n = 1$) and width A.

DISCUSSION

The presence of radiographic abnormalities in household contacts of asbestos workers has received growing attention since the first reports. In 1976, a study of the household contacts of workers in an asbestos factory manufacturing insulation materials found a 35% prevalence of small parenchymal opacities and pleural plaques consistent with asbestos exposure (3). A second study of 60 wives of Los Angeles shipyard workers showed a lower overall prevalence of similar radiographic abnormalities (11.3%) (4). Both groups of investigators postulated that the exposure to asbestos occurred via asbestos dust in the work clothes and hair of the workers (3).

Pleural plaque formation is the most common manifestation of asbestos-related changes in the chest, regardless of the type or degree of exposure. Eventually, at least one-half of asbestos-exposed workers will show some radiographic abnormalities, with pleural plaque formation being by far the most common (5).

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Table 3
 Year of Initial Exposure

	Normal Radiographs (n = 75)	Abnormal Radiographs (n = 18)	P
Mean	1958	1952	<.037
SD	10.46	6.89	...
Range	1926-1958	1936-1963	...
Median	1958	1953	<.049

Table 4
 No. of Subjects with Normal and Abnormal Radiographs, according to Decade of Initial Exposure

Decade	Normal Radiographs (n = 75)	Abnormal Radiographs (n = 18)
1920-1929	1	0
1930-1939	3	1
1940-1949	10	7
1950-1959	35	9
1960-1969	18	1
1970-1979	5	0
1980-1989	3	0

The radiographs of patients with limited or household exposure seem to follow the same pattern as those of occupationally exposed workers, but with lower prevalence. Our study showed exclusively pleural changes in this population. Other reports of household exposure agree that pleural changes are the most common abnormalities.

Parenchymal abnormalities such as small nodular opacities are less consistently reported in household contacts (6, 7). None of the women in our program had such abnormalities. In previous studies, the peak incidence of parenchymal opacities has been 17% (3, 6). As in our survey, none of the women in these studies had had direct exposure to asbestos. In the study of Los Angeles shipyard workers the radiographs of 485 women were analyzed (4). The 1976 study included 676 household contacts of workers who handled asbestos directly or performed brake repair work, drywall construction, or shipyard work (3, 6). The lack of parenchymal opacities in our patients may reflect the smaller patient population or a different type of exposure among pipe coverers. Even so, parenchymal changes appear to be a significantly consistent indicator of the effects of asbestos exposure than the presence of pleural plaque, especially with limited household exposure.

Of all the factors in our survey, the presence of pleural plaque appears to

Table 5
 Total Duration of Exposure (yr)

	Normal Radiographs (n = 75)	Abnormal Radiographs (n = 18)	P
Mean ± SD	27.76 ± 10.01	32.28 ± 6.57	<.72
Range	1.0-52.0	23.0-48.0	...
Median	29.00	30.50	<.081

Table 6
 Age of Subjects (yr)

	Normal Radiographs (n = 75)	Abnormal Radiographs (n = 18)	P
Mean ± SD	54.48 ± 8.93	56.94 ± 7.46	<.282
Range	41.0-82.0	42.0-68.0	...
Median	54.00	59.00	<.180

Table 7
 Number of Asbestos Workers in Household

No. of Workers	No. of Subjects	
	Normal Radiographs (n = 75)	Abnormal Radiographs (n = 18)
1	34 (45.3)	6 (33.3)
2	19 (25.3)	8 (44.4)
3+	22 (29.3)	4 (22.2)
Mean*	1.96	2.00

Note.—Workers included husbands, fathers, brothers, and sons. Percentages in parentheses.
 * P < .890.

Table 8
 Cigarette Smoking

Smoking History	No. of Subjects	
	Normal Radiographs (n = 75)	Abnormal Radiographs (n = 18)
Never smoked	34 (45.3)	6 (33.3)
Past smoker	24 (32.0)	10 (55.6)
Current smoker	17 (22.7)	2 (11.1)
Mean pack-years*	36.66	18.37

Note.—Percentages in parentheses.
 * P < .024.

be most dependent on the interval since the household contact's first exposure. In addition, the latency period before radiographic abnormalities appears to be longer than with occupational exposure (6). In our study, the mean latency period for women was 32.8 years, compared with 23.8 years for the workers. The intensity of exposure and total number of years exposed appear to be less important.

The functional abnormalities in our study are somewhat difficult to interpret. The women with pleural plaque formation did show consistently and statistically lower mean values for FEV₁ (P < .028) and FVC (P < .011) than those with normal radiographs (Table 2). However, both mean values remained within the normal range. In addition, there was no statistical difference between the two groups in complaints of dyspnea on exertion. However, the lower values in the women with radiographic abnormalities may be important, as the women with normal radiographs had a mean pack-year smoking histo-

ry of 36 years, versus 18.4 years for the group with abnormal radiographs. A previous study of pulmonary function data in household contacts in the Los Angeles harbor area, which used sensitive measurements including vital capacity and flow rates, thoracic gas volume, and single-breath diffusing capacity for carbon monoxide, documented a significant functional impairment when this group was compared with a control group in Michigan matched for smoking history (8). In that study, the pulmonary function of exposed women with visible signs of asbestos exposure on chest radiographs (pleural and parenchymal) was not different from that of exposed women with normal radiographs. Our data, although not corrected for smoking history, further suggest that functional abnormalities in persons with indirect asbestos exposure may appear only after a certain latency period since first exposure.

One finding remains difficult to explain. Three women had more severe radiographic abnormalities than

their husbands. However, each of these women gave a family history of at least one household contact in addition to her husband (a brother, a father, and a father and son). These additional contacts did not participate in our study and may have contributed significantly to the household exposure of these three women.

The significance of pleural disease as a sign of limited or household asbestos exposure is important to recognize. The widespread use of asbestos did not start until the mid-1940s. Since there appears to be a long latency period with this limited exposure, often greater than 30 years, the full extent of disease risk is not yet known. Although we did not find any such cases, it has been shown that household contacts have an increased risk of mesothelioma (9, 10). In addition, studies with longer follow-ups should soon be available to

show whether these levels of asbestos exposure are sufficient to cause disabling disease other than mesothelioma (6).

Although the data on the risks of household exposure to asbestos are far from complete, chest radiography is clearly a valuable tool. It is important for radiologists and clinicians to be aware of the significance of pleural plaque in women without other radiographic abnormalities. ■

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