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Airway Disease in Non-Smoking Asbestos Workers

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ABSTRACT. Ninety-seven non-cigarette-smoking white male insulators from the midwestern United States had significantly reduced forced expiratory volume in 1 second ($FEV_{1.0}$) ($P < .0017$) and forced expiratory flow from 75 to 85% of expired volume (FEF_{75-85}) ($P < .042$) when compared to a reference population of Michigan male nonsmokers. There were parenchymal opacities with a profusion of 1/0 or greater in 7 and pleural changes in 13 of these 97 nonsmokers. Asbestos, in the absence of cigarette smoke effects and other diseases, appears to decrease airflow, probably by the distortion of small airways (< 2mm) by peribronchiolar fibrosis. This stiffening of the lung parenchyma protects midflow (FEF_{25-75}) as the fibrosis increases the lung's radial traction on airways larger than 2 mm. This observation contributes to the natural history of physiological impairment due to asbestos disease.

IT IS generally agreed that severe asbestosis reduces lung volume and that it reduces air flow only late in the course of the disease. This picture of asbestosis is derived from studies in which 75% to over 90% of workers studied had smoked cigarettes. Too few nonsmokers have been available to examine the effect on pulmonary function of asbestos alone. Reductions in air flow as measured by the forced expiratory volume in one second ($FEV_{1.0}$) have been regarded as a late sequelae of severe loss of volume or as reflecting the effects of cigarette smoking or of chronic bronchitis due to industrial or other exposures. Recently, attention has been focused on the earlier diagnosis of asbestosis, particularly its detection by radiography of the chest employing the pneumoconiosis criteria of the International Labor Organization (ILO).[1] Screening programs have provided opportunities to detect and study early disease associated with asbestos exposure. One of the questions is whether asbestosis produces physiological abnormalities of the lung prior to its causing disease which is radiographically detectable. The second question is whether the airways are primarily involved early in asbestos disease. The latter issue is important in apportioning causal responsibility for impairment between asbestos exposure and cigarette smoking.

This study examines the degree to which the airways obstruction, particularly small airways obstruction, was present in non-cigarette-smoking workers who were exposed to asbestos as insulators. It also uses smoking-specific comparisons and predicted values, to subtract the effect of smoking to determine whether smoker's pulmonary functions show additive or even synergistic effects.

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METHODS

We studied 416 white asbestos insulators from six midwestern cities: Cleveland, Akron, Dayton and Youngstown, Ohio; Detroit, Michigan; and South Bend, Indiana. Ninety-seven subjects had never smoked cigarettes, 172 were ex-cigarette smokers, and 147 were current smokers. The nonsmokers were analyzed in detail for evidence of airway obstruction unconfounded by the effects of cigarette smoking. Ages of the nonsmokers ranged from 19 to 69 yr, with a mean age of 40.0 yr. They were actively employed at the time of study.

We administered a respiratory questionnaire derived from the Medical Research Council bronchitis questionnaire with additional questions on asthma and on occupational exposures. It defined the time of initial asbestos exposure, duration and intensity of exposure, and exposure to other dusts, fumes, and aerosols. Chest radiographs were standard posteroanterior 14" x 17" films taken at a 6-ft distance at full inspiration and were read for asbestosis according to the ILO classification[1] by an American College of Radiology-certified "B" reader. Spirometry was performed using methods and equipment which met the American Thoracic Society criteria.[2] Reference values were those of Miller et al.[3] Thus, the insulator's spirometric values were compared with those of geographical controls obtained in a cross-sectional study of a stratified random sample of Michigan and expressed as percent predicted. The comparisons were made to all white male Michigan subjects in each smoking category, including those with cough and sputum, not just to normal subjects.

RESULTS

The mean values for age, height, forced vital capacity (FVC), $FEV_{1.0}$, forced expiratory flow from 25 to 75 percent of expired volume (FEF_{25-75}), and forced expiratory flow from 75 to 85 percent of expired volume (FEF_{75-85}), together with percent predicted are shown in Table 1. In asbestos-exposed nonsmokers, FEF_{75-85} and $FEV_{1.0}$ were reduced. The current smokers showed lower values despite being compared to smokers as did the ex-smokers whose values were lowest. The composite flow-volume diagram in Figure 1 shows the reduction in terminal flow and in $FEV_{1.0}$ with an apparent increase in midflow, FEF_{25-75}.

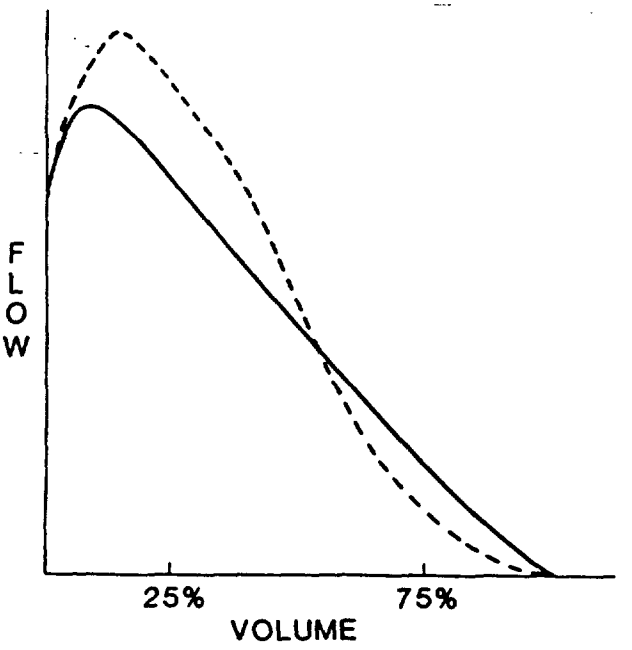

Fig. 1. ***Dashed line*** **represents a composite flow volume curve for nonsmoking asbestos workers.** ***Solid line*** **is a normal flow volume curve. FEF_{75-85} is decreased but FEF_{25-75} is increased in these workers.**

Table 2.—Age and Height Adjusted Differences in Nonsmokers Insulators Minus Reference Population of Michigan Men

	Adjusted Difference	Standard Error of Difference	P
FVC	-0.124	0.084	0.1400
$FEV_{1.0}$	-0.221	0.070	0.0017
Log FEF_{25-75}	0.061	0.039	0.1170
Log FEF_{75-85}	-0.101	0.049	0.0420

The age- and height-adjusted differences of the spirometric indices (asbestos workers minus Michigan) for nonsmokers are presented in T ble 2. Values for the insulators were significantly smaller than those for the Michigan population's nonsmokers in $FEV_{1.0}$ and in log FEF_{75-85}. In modelling the Michigan comparison group

Table 1.—Mean Values and Percentage Predicted for Midwestern Insulators as Compared to Michigan Men

Variable	Nonsmokers		Ex-smokers		Current Smokers	
	Observed	(% Predicted)	Observed	(% Predicted)	Observed	(% Predicted)
Number	97		172		147	
Age	40.0		44.0		48.2	
Height	69.3		69.0		69.1	
FVC (L)	4.90	(97.7)	4.45	(90.5)	4.47	(92.5)
$FEV_{1.0}$ (L)	3.81	(92.4)	3.27	(86.7)	3.38	(90.5)
FEF_{25-75} (L/sec)	4.09	(105.4)	3.10	(96.7)	3.28	(101.6)
FEF_{75-85} (L/sec)	1.08	(92.4)	0.77	(74.5)	0.73	(81.5)

log FEF_{75-85} and log FEF_{25-75} were related linearly to age and height just as FVC and $FEV_{1.0}$ were direct linear functions of age and height. There were parenchymal irregular opacities with a profusion of 1/0 or greater in 7 and pleural changes in 13 of the 97 nonsmokers. The only measure we had of exposure intensity was self-reported by questionnaire, and it was not predictive of either radiographic or spirometric abnormality. Twenty-one of the 97 nonsmokers (21.6%) had a history of chronic bronchitis.

As a group, asbestos-exposed nonsmoking insulators had significantly lower ($P < .042$) terminal airflows as indicated by FEF_{75-85} than a comparison population from the same geographic area. $FEV_{1.0}$ was significantly lower ($P < .0017$) for the insulators as well, and was 92.4% of the percent predicted. Although the mid-flows in this group were slightly greater than those of the controls, the FVC was smaller by 0.124 L. These differences were not statistically significant. The decreases in FEF_{75-85} and $FEV_{1.0}$ in current smokers and ex-smokers exceeded those in nonsmokers because these were smoking-specific comparisons. Thus, subtraction of smoking effect revealed that smokers exposed to asbestos still had greater average decreases than nonsmokers.

DISCUSSION

The reduction in flow is small airways is consistent with the observation of distortion of these airways by peribronchial fibrosis in asbestos-exposed individuals observed 50 yr ago[4] and recently extended.[5] The modest reduction in $FEV_{1.0}$ reflects the contribution of small airways to the volume expired in the first second. The apparent increase in midflow is consistent with increased radial traction resulting from fibrosis holding open airways larger than 2 mm in diameter. The relative preservation of FEF_{25-75} in the nonsmoking insulators and in the smokers as well, seems to confirm the fact that, in general, insulators have stiffer lungs. Thus, in the nonsmoking insulators FEF_{25-75} was not decreased, in contrast to the overall decrease in flows found in "industrial bronchitis."[6] This was despite a high prevalence of chronic bronchitis (21.6%) in these men.

The pattern which emerges for these nonsmoking asbestos-exposed workers is one of decreased airflow in small airways and stiffening of the lung parenchyma (Fig. 1). None of the nonsmokers in this study had severe asbestosis, i.e., a profusion of opacities of 2/2 or greater by ILO criteria. Because of limited data on more advanced stages of the disease in nonsmokers, additional subjects with more severe asbestosis will be required to complete this analysis. However, it is predicted that the physiologic course should be that of other interstitial diseases, such as sarcoidosis,[7] at least as revealed by spirometry. Other studies of workers have shown that the FVC and FEF_{25-75} decrease with increasing exposure measured in particle years and with increasing radiographic change.[8-13] These studies included smokers and nonsmokers. Because insulators and shipyard workers included a high proportion of smokers in the past, i.e., up to 85%, it has been difficult to compile sufficient data on lifelong nonsmokers exposed to asbestos to examine the effects of asbestos alone on airways.

This study adds to the evidence that asbestos alone produces a small airway lesion which not only can be seen pathologically as was observed 50 years ago by Gloyne,[4] but can be measured physiologically. Further studies of larger numbers of insulators covering a broader array of physiologic changes, an increased profusion of irregular opacities, and perhaps, examining those with asbestos pleural thickening and plaques are needed to resolve the stages of physiological impairment as asbestosis progresses. The natural history of asbestosis resulting from the exposure levels of the last two decades, of which this study contributes, remains to be completed.

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