Thickening of pulmonary interlobar fissures: exposure-response relationship in crocidolite and amosite miners

A. SOLOMON¹, L. M. IRWIG¹, G. K. SLUIS-CREMER², R. GLYN THOMAS²,
AND R. S. J. DU TOIT³

From the ¹National Research Institute for Occupational Diseases of the South African Medical Research Council, ²Medical Bureau for Occupational Diseases and ³Air Quality Section of the Department of Mines

ABSTRACT In a cross-sectional study of all white and mixed-race men employed at South African crocidolite and amosite mines, data on duration of asbestos exposure and radiological findings were available for 1692 men, 94% of the total population. Postero-anterior radiographs were read by three experienced readers. Abnormality was regarded as present if reported by at least two of them. The reading included an assessment of whether interlobar fissures were not visible, were visible but not thickened, or were thickened according to criteria shown in a reference radiograph. Fissures which were visible but not thickened were seen in almost half the men and were not more common in men with longer asbestos exposure. On the other hand, thickened fissures increased in prevalence from about 2% in those who had worked with asbestos for 7 years or less, to 25% in those with more than 15 years' asbestos exposure. Some other asbestos-associated pleural or parenchymal abnormality occurred in 69% of men with thickened fissures. The prevalence of thickened fissures as an isolated abnormality was also related to the duration of asbestos exposure. Because its prevalence is related to duration of exposure, and its recognition is not subject to excessive inter-observer variation, we suggest that thickening of the fissures is a valuable sign in the radiological assessment of workers exposed to asbestos.

Pleural thickening of the chest wall is included in the ILO U/C international classification of radiographs of pneumoconioses (International Labour Office, 1972). There is good evidence from studies examining exposure-response relationships that this abnormality is largely attributable to asbestos exposure (Becklake, 1976; Irwig *et al.*, 1978). It has been suggested from case studies that thickening of the interlobar fissures may also be a result of asbestos exposure (Solomon and Webster, 1976). This causal hypothesis can be tested by examining exposure-response relationships (Hill, 1965). In this study, therefore, we have determined the prevalence of thickened fissures in relationship to the duration of asbestos exposure.

Methods

The data were derived from a study designed to determine the relationship between exposure to as-

bestos and radiological abnormality. The selection of the sample and study methods have been described elsewhere (Irwig *et al.*, 1979). In brief, the study included all white and mixed-race men in the employ of South African crocidolite and amosite mines and mills at some time between 1970 and 1975. Sufficient information was obtained about 1692 (94%) of these 1801 men to enable them to be included in the analyses. The duration of work in asbestos mines and mills was known for each man.

A postero-anterior chest radiograph at 6 feet centring on the fourth dorsal vertebra was available. These radiographs were taken with medium speed screens using exposure factors varying from 60 to 65 Kv and 7 mAs to 20 mAs, depending on the man's build. The chest radiograph of each man was read independently by three experienced readers according to the ILO U/C International Classification of Radiographs of Pneumoconioses (International Labour Office, 1972). No information about the age or mining experience of individual men was available to the readers. In addition to the features in the

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Fig. 1 Reference radiograph for thickened fissures. Area to the right of the arrow is the lower limit of thickening.

ILO U/C classification, the appearance of the minor (horizontal) interlobar fissure was recorded as not visible, visible but not thickened or thickened according to a reference radiograph (Fig. 1). Major (oblique) fissures, which are not normally seen on postero-anterior radiographs (Felson, 1973), were recorded as thickened in the few cases in which they were seen. Each type of radiological abnormality was regarded as present if reported by at least two of the three readers.

Results

Fissures which were visible but not thickened were found in 793 men (46.9%) and thickened fissures in 86 men (5.1%). The prevalence of fissures which were visible but not thickened showed no clear relationship to asbestos exposure. However, the prevalence of thickened fissures increased from about 2% in men who had worked with asbestos for 7 years or less, to 24.7% in men who had worked with asbestos for more than 15 years (Table 1). The prevalence of thickened fissures was also related to age, but the effect of duration of asbestos exposure

remained significant after taking age into account (Table 2).

Thickened fissures were often found in association with other pleural and parenchymal abnormalities, and only 27 of the 86 men had thickened fissures as an isolated abnormality (Table 3). The prevalence of thickened fissures in the absence of other abnormalities was still significantly related to the duration of asbestos exposure (Table 4). This relationship remained significant even after taking age into account ($\chi^2 = 16.4$, $P < 0.01$; Gokhale and Kullback, 1977).

We have examined the inter-observer variation for reading thickening of interlobar fissures compared with that for pleural thickening of the chest wall. In Figure 2, the number of radiographs read as abnormal is shown in a separate circle for each reader. Agreement between readers is represented by overlapping of the circles. Of the 197 men in whom at least one reader reported thickened fissures, 36 (18.3%) were agreed by one other reader and 50 (25.4%) by two other readers. For comparison, pleural thickening of the chest wall was reported present by at least one reader in 180 men, of which

Table 1 Visibility of fissures by years of asbestos exposure

Years of asbestos exposure		Fissures							
Category	Mean	Not visible		Visible but not thickened		Thickened		Total	
		No.	%	No.	%	No.	%	No.	%
≤1.00	0.4	278	48.9	279	49.0	12	2.1	569	100.0
1.01- 3.00	1.9	198	56.9	143	41.1	7	2.0	348	100.0
3.01- 7.00	4.7	157	45.1	184	52.9	7	2.0	348	100.0
7.01-15.00	10.4	131	46.6	126	44.8	24	8.5	281	99.9
>15.00	20.8	49	33.6	61	41.8	36	24.7	146	100.1
Total		813	48.0	793	46.9	86	5.1	1692	100.0
Test applied to:				df	χ ²	P	χ ² for trend	P	
Whole table				8	159.1	<0.001	Not applicable	—	
'Not visible' vs 'visible but not thickened' fissures				4	12.2	<0.05	2.0	—	Not significant
'Not visible' and 'visible but not thickened' vs 'thickened' fissures				4	147.0	<0.001	131.9	—	<0.001
Statistical tests as in Armitage, 1971.									

Table 2 Thickened fissures by years of asbestos exposure and age

Years of asbestos exposure	Age								
	≤30 years			31-40 years			>40 years		
	No. of men	No.	Prev. %	No. of men	No.	Prev. %	No. of men	No.	Prev. %
≤1.00	325	1	0.3	155	2	1.3	89	9	10.1
1.01- 3.00	180	0	0	102	1	1.0	66	6	9.1
3.01- 7.00	146	1	0.7	103	1	1.0	99	5	5.1
7.01-15.00	37	0	0	118	5	4.2	126	19	15.1
>15.00	0	0	—	41	3	7.3	105	33	31.4
Total	688	2	0.3	519	12	2.3	485	72	14.8
Variables (added stepwise)		χ ² *	df	P					
Age		131.1	2	<0.001					
Years of asbestos exposure		37.3	4	<0.001					

*Based on multivariate techniques for the analysis of multidimensional contingency tables (Gokhale and Kullback, 1977).

Table 3 Thickened fissures by other radiological abnormality

Other abnormalities	Thickened fissures		
	Absent	Present	Total
None	1456	27	1483
Parenchymal	61	19	80
Pleural	67	19	86
Both parenchymal and pleural	22	21	43
Total	1606	86	1692

χ² = 312.7, P < 0.001.

Table 4 Thickened fissures in the absence of other radiological abnormality by years of asbestos exposure

Years of asbestos exposure		No. of men		'Isolated' thickened fissures	
Category	Mean	No.	Prevalence %	No.	Prevalence %
≤1.00	0.4	569	7	1.2	
1.01- 3.00	1.9	348	3	0.9	
3.01- 7.00	4.7	348	4	1.1	
7.01-15.00	10.4	281	4	1.4	
>15.00	20.8	146	9	6.2	
Total		1692	27	1.6	

χ² = 21.6, P < 0.001.

χ² for trend = 15.5, P < 0.001.

42 (23.3%) were agreed by one other reader and 34 (18.9%) by both other readers.

Discussion

The prevalence of fissures which were visible but not thickened was similar to that reported in the literature (Felson, 1973) and did not increase with increasing duration of asbestos exposure. On the other hand the prevalence of thickened fissures showed a strong relationship to the duration of asbestos exposure, supporting the hypothesis that asbestos was the cause. The prevalence of thickened fissures also depended on age. The relative dependence on asbestos exposure and age was similar to that found for parenchymal abnormality and pleural abnormality (defined as the presence of pleural thickening of the chest wall, costophrenic angle obliteration, or pleural calcification) (Irwig *et al.*, 1979).

Because parenchymal and pleural abnormalities and thickened fissures are more common in men with longer asbestos exposure, it is not surprising that they often occur together. However, as judged by the exposure-response relationship, thickened fissures may indicate a reaction to inhaled asbestos even

Fig. 2 Recording of abnormality by readers A, B and C.

when they occur in the absence of parenchymal and pleural abnormalities. Examination of serial films of the men who had thickened fissures as an isolated abnormality suggests that the fissures thicken slowly and progressively.

Radiological recognition of thickening of the fissures is subject to no more inter-observer error than is the case with pleural thickening of the chest wall. Pleural thickening of the chest wall may be parietal or visceral (Sluis-Cremer and Webster, 1972), although this differentiation cannot be made radiologically. The observation of thickened fissures is therefore the only radiographic method of diagnosing involvement of the visceral pleura.

We suggest the inclusion of this sign, preferably with separate recording of major and minor fissures, in studies of the effects of asbestos exposure. It should also be included in any future amendments

to the ILO U/C International Classification of Radiographs of Pneumoconioses.

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