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Cement, Asbestos, and Cement-Asbestos Pneumoconioses

A Comparative Clinical-Roentgenographic Study

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The incidence and characteristics of cement-asbestos pneumoconiosis were compared with those of asbestosis and cement pneumoconiosis in three homogeneous samples of cases.

The clinical, functional, and radiological features of cement-asbestos pneumoconiosis are similar to those of classical asbestosis, but the observed changes are less common and occur after a longer exposure.

About two thirds of all the asbestos produced in the world is consumed by the cement-asbestos (CA) industries.[1,2] Medium- and short-fibered serpentine (chrysotile) is the most widely used variety, whereas long-fibered amphibole (crocidolite) is used less often. Selection of substance depends on whether it is desired to endow the finished product with greater flexibility or, in the case of crocidolite, strength and resistance to acids.

The asbestos is mixed in a proportion of 15% to 20% with artificial Portland cement that consists of calcium silicate, tricalcium aluminate, and tricalcium ferrite. Portland cement also contains from 1% to 5% of free silica (SiO_2) and smaller amounts of other compounds, mainly CaO, as well as aluminium, iron, and magnesium oxides.

Exposed workers may develop a combined pneumoconiosis in which fibrosis caused by the asbestos, mostly in the middle and lower zones of the lungs, is associated with rounded lesions and hilar adenopathy attributable to the silica.[3]

The pathologic changes are therefore produced by the partly unaltered asbestos fibers in the mixture[4,5] and partly by the cement that has been shown experimentally to have a sclerotic effect on the peritoneum in the rat when its content of free silica approximates 5%.[4] Nordmann and Sonnenberg[3] have suggested that the enlargement of the hilar lymph nodes may be due to the lime.

The incidence of this pneumoconiosis, usually diagnosed as asbestosis, was found to be 5% in exposed workers in CA industries near Naples[2] and 12%[6] or 12.9% in CA factories near Casale.[6]

DeRosa et al[7] investigated the distribution of the workers with asbestosis in the various workshops. They found that 50% of those employed in preliminary processing of the fibers and 15% to 18% of those employed in dry manipulation of the finished product were affected.

Rubino and Scansetti[8] found that the incidence of asbestosis among exposed workers in CA industries was one half of that found among exposed workers in brake and friction material and one third that of workers in asbestos textile factories.

The incidence of asbestosis is very high in India[10] (27% of exposed subjects) and in Egypt,[11] where 81% of the workers exposed to CA for more than 20 years were found to be affected, but low in West Germany where 23 of 4,500 (approximately 0.5%) exposed workers were found to be affected and were awarded compensation for asbestosis from 1958 to 1967.[3] Bohlig[1] also found that the incidence of asbestosis was 11 times lower in the CA industry than in other industries in which asbestos is used.

METHOD

The purposes of this investigation were (1) to ascertain the incidence of CA pneumoconiosis that, as indicated above, seems to differ widely in different countries, especially when compared to that of classical asbestosis and (2) to define the clinical features of this pneumoconiosis that is attributable to the combined, although different, action of two dusts—cement—a possible cause of silicosis, and—asbestos—that is present under the form of asbestos fibers, throughout the entire manufacturing process and in the finished product.

Three sample groups, each numbering 100 subjects, were examined. The first, denominated the cement or C group, was selected from a series of 133 workers exposed to the dust formed in quarrying marl for natural cements or in the manufacture of natural or artificial cements. The second, denominated the cement-asbestos or CA group, was selected from a series of 642 workers employed in CA factories. The third, denominated the asbestos or A group, was selected from a series of 341 workers employed in asbestos textile factories.

Starting from the less numerous series a corresponding subject in each of the two

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Table 1.—Physical Findings

Group	Clubbing		Cyanosis		Bronchial Rales	Crepitant Basal Rales	Pleural Friction Rub
	Slight	Severe	Slight	Severe			
CA	3	0	12	0	11	8	3
C	1	0	1	0	4	7	0
A	8	2	16	3	4	13	5

Table 2.—Electrocardiographic Signs of Right Cardiac Impairment

Group	"Pulmonary" P wave	Delayed Right Intraventricular Conduction	
		Focal Bundle Branch Block	Complete Bundle Branch Block
CA	1	2	2
C	4	1	1
A	3	2	2

Table 3.—Respiratory Function Tests*

Group	$\frac{VC}{\text{theor VC}} \cdot 100$ (Mean)	$\frac{FEV_{1.0}}{\text{theor FEV}} \cdot 100$ (Mean)	$\frac{FEV_{1.0}}{VC} \cdot 100$ (Mean)
CA	69.80	69.97	69.49
C	75.95	72.93	65.19
A	66.53	66.53	69.88

* VC and $FEV_{1.0}$ are expressed in percent of the standard value established by the European steel and coal community.

other series was selected by computerization so as to obtain groups of three cases of equivalent (± 5 years) age and duration of exposure. A total of 33 subjects in the series exposed to cement dust were discarded, no corresponding subject having been found in one or both of the two other groups, thus leaving 100 series of three subjects each.

The mean age of the three samples ranged from 54.5 to 55.5 years and the mean duration of exposure from 18.5 to 21 years.

Group	Mean Age, yr	Mean Exposure, yr
CA	54.5	19.9
C	55.5	21.0
A	55.5	18.5

The three groups were compared taking into account the incidence of various physical (clubbing, cyanosis, bronchial and crepitant rales, pleural friction rub), electrocardiographic (evidence of cardiac impairment on the right such as pulmonary P wave and delayed intraventricular conduction on the right), and roentgenographic (1968 "extended" International Labor Office [ILO] classification) findings, and the mean values observed in pulmonary function tests (vital capacity [VC] and forced expiratory volume [$FEV_{1.0}$] expressed in percent of the standard values established by the European coal and steel community, $FEV_{1.0}$/VC ratio).

RESULTS

Clubbing of the fingers and cyanosis (Table 1) were more common in the A group (10% and 19% of the cases, respectively) than in the C group. Cyanosis was present in 12% of cases and clubbing only in 3% in the CA group.

Crepitant basal rales, a characteristic symptom in asbestosis, were also more common in the A group (13% of the cases) but were found as often in the CA group (8% of the cases) as in the C group (7% of the cases).

Symptoms of bronchitis were especially common in the CA group (11% of the cases) and were found less often in the two other groups (4% of the cases in both). Pleural friction rub was found only in the A and CA groups (5% and 3% of the cases, respectively).

Electrocardiographic signs of cardiac impairment on the right were uncommon. Their incidence did not differ significantly in the three groups (Table 2). Right ventricular hypertrophy or strain was never observed.

The results of pulmonary function studies are shown in Table 3. The type and severity of the observed changes differed in the three groups. Mild, predominantly obstructive impairment of pulmonary function was found in the C group and more severe impairment, of a predominantly restrictive type, in the A group, in which the $FEV_{1.0}$/VC ratio was low but still within the normal range. The pattern in the CA group was similar to that observed in the A group, but the degree of impairment was less severe and of a less clearly restrictive type.

The roentgenographic findings (1968 ILO classification) are shown in Table 4 in which only the type of the shadows, but not their extension and profusion, is considered. Table 4 shows the number of positive cases. As customary in this type of analysis, cases showing only minimal (0/1) profusion of the shadows are omitted. Figure 1 groups the cases of rounded shadows, irregular shadows, and those in which rounded and irregular shadows were present together.

Irregular shadows were found in three quarters of the cases in the A group and in two thirds of those in the CA group. The incidence of type s was about the same in the two groups. Irregular shadows, mostly (28 out of 33 cases) type s, were present in one third of the C group. Rounded shadows were virtually never found except in subjects exposed to silica, even if exposure was not severe. They were found in 10% of the CA group and in 18% of the C group. None of the subjects in the A group had rounded shadows alone. Three had rounded shadows associated with irregular shadows (the group with mixed shadows also includes cases classified as grade 0/1 of profusion). Types u and r were not found in any of the three groups.

The profusion and extension of the observed roentgenographic shadows are shown in Tables 5 and 6. For practical reasons, the findings are grouped together as follows: profusion—low (0/1, 1/0, 1/1), medium (1/2, 2/1, 2/2) and high (other classes); extension—small (two lung zones), medium (four lung zones), and great (more than four lung zones).

In the case of irregular shadows, especially type t, high degrees of pro-

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fusion were much more common in the A group. Cases classified as types s and t with a high degree of profusion of the shadows were found in the CA group, although not as often as in the former group. No type t with a high degree of profusion was found in the C group.

Rounded shadows in the A and CA groups never showed a high degree of profusion. Two cases of rounded shadows (type q) in the C group showed a high degree of profusion.

The incidence of roentgenographic changes in the pleurae is shown in Fig 2. The conclusion seems warranted that, especially from this standpoint, CA pneumoconiosis is similar to classical asbestosis. Obliteration of the costophrenic angle and thickening of the parietal pleura without calcification were found together in about one quarter of the cases in the CA group and in about one sixth and one quarter, respectively, of the A and C groups. Calcifications of the parietal and diaphragmatic pleura were found in 7% of cases in the CA group and in 9% of cases in the A group. All these changes were much less common in the C group. However, one of the cases in this group had calcifications of the parietal pleura and another calcifications of the diaphragmatic pleura.

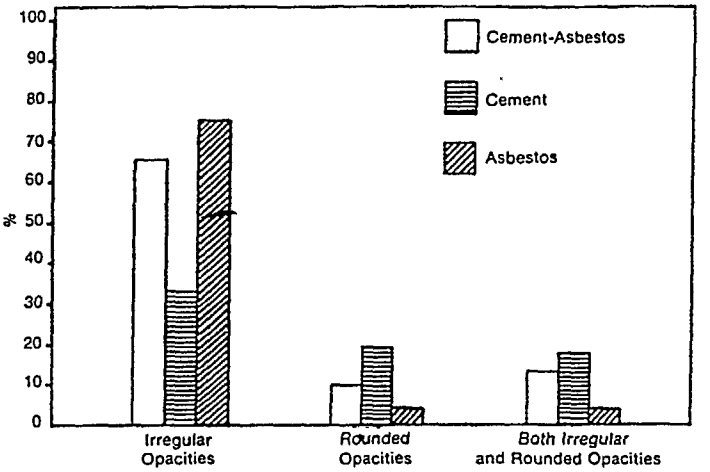


Fig 1.—Incidence of the various types of roentgenographic shadows (1968 "extended" ILO classification). Cases showing only a minimal degree of profusion of the shadows (grade 0/1) are omitted except in the case of the group with associated irregular and rounded shadows.

Table 4.—Incidence of the Various Types of Roentgenographic Shadows*

	Irregular Shadows		Rounded Shadows	
Group	Type s	Type t	Type p	Type q
CA	55	11	6	4
C	28	5	11	7
A	53	22	1	2

* 1968 "extended" ILO classification.

Table 5.—Profusion of the Various Types of Roentgenographic Shadows

	Irregular Shadows						Rounded Shadows					
	Type s			Type t			Type p			Type q		
Group	L*	M	H	L	M	H	L	M	H	L	M	H
CA	20	38	6	4	8	2	4	3	0	5	1	0
C	18	19	4	1	4	0	10	9	0	2	3	2
A	18	27	16	0	9	13	0	1	0	1	1	0

* L, low; M, medium; and H, high (1968 "extended" ILO classification).

Table 6.—Extension of the Various Types of Roentgenographic Shadows

	Irregular Shadows						Rounded Shadows					
	Type s			Type t			Type p			Type q		
Group	S*	M	G	S	M	G	S	M	G	S	M	G
CA	23	32	9	2	9	3	3	3	1	1	5	0
C	16	22	3	1	4	0	3	14	2	1	4	1
A	24	21	16	1	8	13	0	1	0	0	2	0

* S, small; M, medium; and G, great (1968 "extended" ILO classification).

COMMENT

Our findings point to the conclusion that CA pneumoconiosis is similar to classical asbestosis although less advanced at an equal duration of exposure.

1. Respiratory or cardiorespiratory insufficiency was found in a number of cases in the CA group, although less often than in the A group, but not in the C group.

2. The pattern of impairment of respiratory function was the same (predominantly restrictive) in the CA and A groups. Moderately impaired respiratory function (predominantly obstructive) was found in the C group. The changes were more severe in the A group.

3. Irregular shadows were found in all three groups. Their incidence was similar in the CA and A groups (respectively two thirds and three quarters of the cases) but much lower in the C group (one third of the cases). Quantitative differences were observed between the A and CA groups. The most advanced pictures and the highest degrees of profusion were found in the A group as compared with the CA group. Advanced roent-

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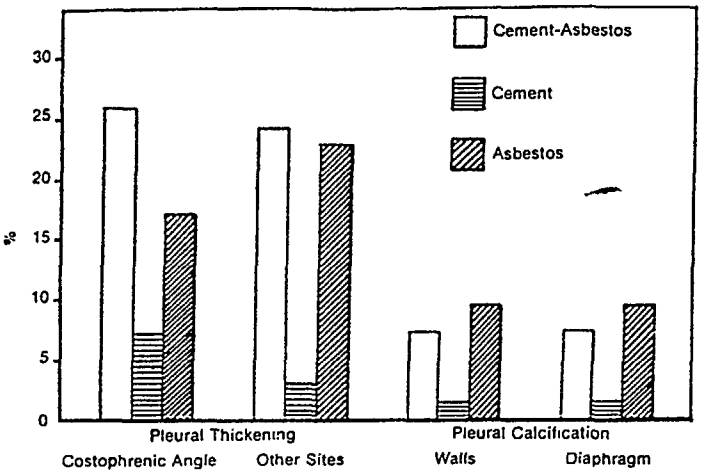


Fig 2.—Incidence of roentgenographically demonstrable pleural changes.

genographic features were very uncommon in the C group, in which high degrees of profusion were never observed.

4. Involvement of the pleurae was found both in the CA group and in the A group. These were the only groups in which cases with pleural friction rub were found. Obliteration of the costophrenic angle without calcification was more common in the CA group than in the A group, whereas pleural calcifications were more common in the A group, although the difference between the two groups was not very great.

These findings indicate a similarity between CA and A pneumoconiosis, although certain minor differences can also be distinguished. Symptoms of bronchitis were more severe in the CA group than in the A or C groups. A "synergistic" action of the two dusts or, perhaps, the microclimatic environmental conditions may be involved here.

Rounded shadows unassociated with irregular shadows were not found in the A group, but were found in the CA group and, especially, in the C group. The incidence of rounded shadows associated with irregular shadows in the CA group was about half of that found in the C group but was very low (3% of the cases) in the A group.

These findings bring to mind the recently proposed classification of CA pneumoconiosis as asbestosis, asbesto-silicosis, or even simple silicosis[12,13] (definable as such from the clinical-roentgenographic findings): when the functional pattern observed in patients with predominantly or exclusively rounded or irregular shadows was examined separately it was found that subjects with irregular shadows showed mainly a reduction of the VC, total lung capacity, and pulmonary diffusing capacity for carbon monoxide, single breath and those with rounded shadows showed an increase of the residual volume whereas the $FEV_{1.0}$ did not differ significantly between the two groups.[12,14] The results of functional tests in our patients gave similar results. Our results point to the conclusion that the incidence of CA pneumoconiosis is high in the circumstance of a long duration of exposure (average 20 years in our series). This suggests that the figures reported by other investigators are too low. However, Bohlig[4] stressed the great mobility of workers in this type of industry in West Germany. This does not apply to the Casale area in which our investigations were carried out, as proved by the high mean duration of exposure in our cases.

From almost every standpoint CA pneumoconiosis is similar to classical asbestosis and can be diagnosed as such. It occurs after a longer exposure,[9] but is common and has a similar morphological and functional picture. This was also suggested by Calamari et al,[8] who also carried out their investigations in the Casale area. The findings of Vigliani,[15] indicating that the CA industry is responsible for the majority of cases of asbestosis diagnosed in Italy during the recent past, can be explained by the fact that in our country the CA industry also includes large factories (employing more than 1,000 to 2,000 workers), a fact that does not apply to other asbestos industries (mining, textile, brake and friction material).

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