

Asbestos Exposure in a Shipyard Area, Northeastern Italy

Claudio BIANCHI*, Alessandro BROLLO and Lucia RAMANI

Laboratory of Pathological Anatomy, Hospital of Monfalcone, 34074 Monfalcone, Italy

Received March 14, 2000 and accepted May 31, 2000

Abstract: The Monfalcone area, northeastern Italy, is a small industrial district (population 60,000), with a large shipyard. In order to monitor asbestos exposure in this area, a series of 3,640 necropsies, carried out at the Monfalcone Hospital between October 1979 and September 1998, were investigated. The thoracic cavities were examined for pleural plaques; these were classified into three classes (small, moderate, large). Routine histological sections of lung tissue were examined for asbestos bodies. Isolation and counting of asbestos bodies were performed in 1,075 cases. Lifetime occupational data were collected in 1,277 cases. Pleural plaques were observed in 70.5% among men and in 23.8% among women. The prevalences of pleural plaques did not show significant variations during the study period. Asbestos bodies were found on routine lung sections in 23.7% of men and 3.0% of women. The shipyard workers, the most numerous category in the series, were characterized by high prevalence of pleural plaques (total 86.7%, large 32.4%), high prevalence of asbestos bodies on routine lung sections (35.3%), and high amounts of lung asbestos bodies after isolation. The present data indicate that asbestos exposure may reach alarming levels in the shipyard areas.

Key words: Asbestos exposure, Asbestos bodies, Pleural plaques, Shipbuilding, Necropsy

Introduction

A lot of data indicate that asbestos exposure and its effects have become major health problems in the industrial world:

- (1) the incidence of malignant mesothelioma, a sentinel event of the asbestos exposure, shows a dramatic increase in various industrialized countries^{1–3};
- (2) the number of the occupational categories at risk for asbestos disease is increasing⁴;
- (3) the results of recent investigations confirm that the risk of asbestos-related mesothelioma persists at low doses¹;
- (4) some studies conducted in the United States⁵ and in Italy⁶ suggest that in the areas with asbestos industries, the risk involves all people resident in the area;
- (5) in many countries, the use of asbestos continues, in other this use has been stopped in the 1980's or in the 1990's. Given the fact that the latency periods in asbestos-related mesothelioma are frequently higher

than 40 years⁷, mesothelioma will represent a serious problem in the next decades, even in the countries where asbestos has been prohibited. A recent analysis predicts that some 250,000 deaths from mesothelioma have to be expected among men of Western Europe over the next 35 years⁸;

- (6) some investigations show that in certain occupational groups, such as the petrochemical industry workers⁹, asbestos-cement workers¹⁰, and shipyard workers¹¹, the proportion of lung carcinomas attributable to asbestos may reach very high percentages (50–70%).

In this context it is opportune:

- a) to monitor exposure to asbestos in the general population;
- b) to identify the groups at higher risk;
- c) to try all the ways in order to neutralize the effects of asbestos among the subjects heavily exposed to asbestos in the past.

The present study, an extension of previous investigations¹², has been performed in the Monfalcone area. This area is a

*To whom correspondence should be addressed.

small industrial district, with a total population of about 60,000 inhabitants, located in northeastern Italy at the border with Slovenia. Monfalcone is called the "shipyard town". A shipyard was opened here in 1907. In the following decades the Monfalcone shipyard became the most important shipbuilding installation in the Mediterranean region. The workforce of the shipyard strongly increased in the 1930's, when the number of workers passed from 2,000 to over 5,000. Moreover in the Monfalcone shipyard, electromechanic shops and aeronautic works were located, employing additional 4-5,000 people. In the 1950's the total number of shipyard workers was about 6,000, and decreased to 3,500-5,000 in the 1960's and 1970's.

The above figures indicate that in the Monfalcone area a majority of the male population has spent some part of their worklife in the shipyard. In the past asbestos has largely been used in the shipbuilding industry⁷. In the present investigation, three indicators of asbestos exposure (occupational history, pleural plaques, and lung asbestos bodies) were examined in a large necropsy series.

Materials and Methods

During the period October 1979–September 1998, 3,685 necropsies were performed at the Hospital of Monfalcone. The 3,640 necropsies carried out in persons aged 15 years or more were included in the study. The necropsies represented percentages ranging between 30 and 45 of the hospital deaths among men, and 20–30% of the deaths among women. In each case the thoracic cavity was carefully examined for pleural plaques. All white ivory patches, unilateral or bilateral, calcified or not, involving parietal pleura were considered as pleural plaques. The plaques were classified into three classes: 1, small; 2, moderate; and 3, large, on the basis of the size of the plaque. Class 1 included the cases with small plaques (1–4 cm in major diameter); class 2 comprised plaques larger than 4 cm in major diameter, but not involving a majority of a hemithorax; class 3 corresponded to cases with plaques involving the majority of a hemithorax. When the two pleural cavities differed one from the other (one side only being involved by the plaques, or both sides being involved, but at different degrees), the classification of the case was based on the aspect of the involved, or of the more seriously involved, side.

In a majority of cases one or more samples obtained from the pleura involved by the plaques, were histologically examined by the routine methods (paraffin inclusion, hematoxylin-eosin staining).

In all the cases some sections of lung tissue, processed

by routine methods were histologically examined for the presence of asbestos bodies.

In 1,075 cases isolation and counting of lung asbestos bodies were performed, after chemical digestion of a sample obtained from the right base¹³.

In 1,277 cases lifetime occupational histories were obtained from the patients' relatives by personal interviews.

Statistical analysis was performed by Epi Info, version 5, from the Centers for Disease Control (Atlanta, GA). The chi-square test was used to compare the prevalences of pleural plaques and those of asbestos bodies in the various groups. The relationship between pleural plaques and presence of asbestos bodies in lung sections was analyzed by the chi-square test for linear trend. The relationships among the various occupations and the asbestos body amounts in digested lung tissue were examined by ANOVA test or by Mann-Whitney two-sample test, after Bartlett's test for homogeneity of variance.

Results

The prevalence of pleural plaques was high among men aged 35 years or more, with small variations from one age group to another (Table 1). Among women there was a progressive increase in the prevalence of pleural plaques from the age group 35–44 years to the group 55–64, with stationary values in the decade 65–74, and decreasing figures in the oldest groups. There were strong differences between the sexes in the prevalences of total plaques ($p < 0.0001$) as well in the prevalences of large plaques ($p < 0.0001$).

Men resident in the Monfalcone area differed in the prevalence of total plaques ($p < 0.0001$) and prevalence of large plaques ($p < 0.0001$) from men resident in other places (Table 2). Among women there was a difference in the prevalences of total plaques ($p < 0.0001$), and in the prevalences of moderate-large plaques ($p < 0.05$). The analysis of residence places revealed that a large majority of people resident outside the Monfalcone district, lived in the immediately adjacent area.

When autopsy cases were subdivided in six categories on the basis of age groups, and of calendar years, not relevant variations were noted (Table 3).

Asbestos bodies were found on routine lung sections in 23.7% of men, and in 3.0% of women. Men resident in the Monfalcone area showed more frequently asbestos bodies than non-residents ($p < 0.0001$) (Table 4). Among women the difference did not reach the statistical significance.

The two sexes differed in the prevalence of lung asbestos body amounts, women very rarely showing more than 10,000

Table 1. Prevalence of pleural plaques in an autopsy series in Monfalcone, Oct. 1979–Sept. 1998, by sex and age group

Age groups (years)	Men					Women				
	No. of cases	Pleural plaques (%)			Total	No. of cases	Pleural plaques (%)			Total
		Class 1	Class 2	Class 3			Class 1	Class 2	Class 3	
15–24	5	0	0	0	0	0				
25–34	12	0	8.3	0	8.3	8	0	0	0	0
35–44	49	18.4	22.4	18.4	59.2	25	8.0	0	0	8.0
45–54	165	18.2	24.2	23.0	65.5	45	13.3	2.2	0	15.5
55–64	399	23.8	25.3	20.1	69.2	128	21.9	6.3	1.6	29.8
65–74	707	25.2	29.7	17.8	72.7	271	20.3	8.1	1.1	29.5
75–84	709	22.1	30.3	21.3	73.8	557	18.3	5.6	0.2	24.1
85–94	207	22.7	27.1	17.9	67.6	333	15.3	3.9	0.6	19.8
95 and over	7	42.9	0	0	42.9	13	0	7.7	0	7.7
Total	2,260	23.0	28.1	19.5	70.5	1,380	17.7	5.5	0.6	23.8

Table 2. Prevalence of pleural plaques in an autopsy series in Monfalcone, Oct. 1979–Sept. 1998, by residence status

Place of residence	Men					Women				
	No. of cases	Pleural plaques (%)			Total	No. of cases	Pleural plaques (%)			Total
		Class 1	Class 2	Class 3			Class 1	Class 2	Class 3	
Monfalcone area	1,940	22.8	29.5	21.4	73.7	1,145	19.6	6.2	0.6	26.4
Other	320	23.8	19.4	8.1	51.3	235	8.5	2.1	0.4	11.0

Table 3. Prevalence of pleural plaques in an autopsy series in Monfalcone, Oct. 1979–Sept. 1998, among subjects resident in the Monfalcone area, by period and age group

Period	Men					Women				
	No. of cases	Pleural plaques (%)			Total	No. of cases	Pleural plaques (%)			Total
		Class 1	Class 2	Class 3			Class 1	Class 2	Class 3	
Age 16–54 y.										
1979–85	96	22.9	21.9	25.0	69.8	31	12.9	3.2	0.0	16.1
1986–91	41	7.3	26.8	17.1	51.2	13	15.4	0.0	0.0	15.4
1992–98	59	16.9	20.3	23.7	60.9	25	4.0	0.0	0.0	4.0
Age 55–110 y.										
1979–85	602	24.6	24.3	25.9	74.8	320	20.6	5.3	0.9	26.8
1986–91	465	21.7	36.1	18.5	76.3	315	22.5	6.3	0.0	28.8
1992–98	677	23.5	31.6	18.9	74.0	441	18.1	7.5	0.9	26.5

asbestos bodies/g dried tissue (Table 5).

The prevalence of asbestos bodies on routine lung sections showed a marked and progressive increase passing from people without plaques to the various classes (1, 2, 3) of plaques ($p < 0.0001$) (Table 6).

The prevalence of asbestos exposure markers showed marked differences among the various occupational categories (Table 7). In particular, the shipyard workers showed significantly higher prevalences of moderate-large plaques ($p < 0.0001$), and significantly higher prevalence of

asbestos bodies on routine lung sections ($p < 0.0001$) when compared with the other groups. The women classified as domestic exposure had cleaned the work clothes of their relatives, employed in the shipyard or in other industries.

The shipyard workers showed higher amounts of lung asbestos bodies in digested lung tissue than the other groups (Table 8). In particular, the shipyard workers significantly differed from the other categories in the percentage of cases with more than 10^4 asbestos bodies/g ($p < 0.0001$).

Table 4. Prevalence of asbestos bodies in lung sections in an autopsy series in Monfalcone, Oct. 1979–Sept. 1998, by sex, age group, and residence status

Age (years)	Men				Women			
	Residents		Others		Residents		Others	
	No. of cases	Positive (%)	No. of cases	Positive (%)	No. of cases	Positive (%)	No. of cases	Positive (%)
16–54	196	22.4	35	8.6	68	0.0	9	0.0
55–110	1,744	26.4	285	9.8	1,076	3.3	226	2.2

Table 5. Number of asbestos bodies isolated after chemical digestion of lung tissue from 1,075 autopsied cases, Monfalcone, Oct. 1979–Sept. 1998

Asbestos bodies*	Men		Women	
	No. of cases	(%)	No. of cases	(%)
0	29	3.2	8	4.4
10 ¹	99	11.1	39	21.4
10 ²	197	22.1	85	46.7
10 ³	244	27.3	42	23.1
10 ⁴	229	25.6	7	3.8
10 ⁵	86	9.6	1	0.5
10 ⁶	9	1.0	0	
Total	893	100	182	100

*No. of asbestos bodies/g dried tissue.

Table 6. Prevalence of asbestos bodies in lung sections and pleural plaques in an autopsy series in Monfalcone, Oct. 1979–Sept. 1998

Pleural plaques	Men		Women	
	No. of cases	Asbestos bodies (%)	No. of cases	Asbestos bodies (%)
Absent	666	4.8	1,051	2.1
Class 1	519	14.1	244	2.9
Class 2	634	32.6	76	9.2
Class 3	441	50.8	8	62.5
Total	2,260	23.7	1,379	3.0

Table 7. Prevalences of pleural plaques and lung asbestos bodies in an autopsy series in Monfalcone, Oct. 1979–Sept. 1998, by occupational group

Occupation	No. of cases	Pleural plaques (%)				Asbestos bodies*
		Class 1	Class 2	Class 3	Total	
Shipbuilding	646	21.2	33.1	32.4	86.7	35.3
Dock and sailors	41	41.5	19.5	9.8	70.8	4.9
Various	153	26.8	20.9	13.1	60.8	11.1
Other industries	232	26.7	11.2	3.4	41.3	4.3
Domestic exp.	141	39.0	11.3	0.7	51.0	2.8
Negative **	64	6.3	1.6	0.0	7.9	0.0
Total	1,277	24.7	23.3	19.0	67.0	20.4

*Prevalence of asbestos bodies (%) on routine lung sections. **Occupational data negative for asbestos exposure.

Discussion

In the present study, asbestos exposure was investigated by analyzing three different parameters, occupational data, lung asbestos bodies, and pleural plaques. Each of such parameters has different degrees of sensitivity, and specificity. On the other hand, the reliability of the information these

parameters may furnish, increases if two or three of them are simultaneously explored.

Occupational history may clearly indicate that an exposure to asbestos has occurred. If the patient has worked as an insulator or if he or she has been employed in asbestos mining or in asbestos industries, there is no doubt about his or her exposure. However, frequently it happens that a person has

Table 8. Numbers of asbestos bodies in digested lung tissue in an autopsy series in Monfalcone, Oct. 1979–Sept. 1998, by occupational group

Occupation	No. of cases	Asbestos bodies (%) [*]			
		<10 ³	10 ³	10 ⁴	10 ⁵ –10 ⁶
Shipbuilding	430	21.4	29.5	33.5	15.6
Dock and sailors	21	57.1	38.1	4.8	0.0
Various	89	51.7	33.7	12.4	2.2
Other industries	111	68.5	24.3	4.5	2.7
Domestic exp.	68	66.2	30.9	2.9	0.0
Negative ^{**}	13	69.2	30.8	0.0	0.0
No data	343	51.6	20.1	21.3	7.0
Total	1075	42.5	26.6	22.0	8.9

^{*}Number per gram dried lung tissue. ^{**}Occupational data negative for asbestos exposure.

been indirectly exposed, as a bystander, and this fact does not always emerge from the occupational history. Moreover, in a lot of cases the patient has worked in a plant that has been closed since various decades. In this setting, it is extremely difficult or impossible, to assess on the only basis of the occupational data, whether or not the exposure has been occurred. However, a given occupational history becomes more easy to interpret, when also objective signs of asbestos exposure are available.

The detection of asbestos in lung tissue is the most direct way of determining, if a given person has been exposed to asbestos. In addition, the examination of the lung for asbestos gives precious information on the intensity of the exposure. The examination of routine lung sections for asbestos bodies, adopted in the present study, is a rather rough method. The advantage is that it may be routinely applied in all the cases. However, several factors reduce the sensitivity of the method: asbestos bodies may be hidden by carbon pigment; asbestos bodies are not rarely irregularly distributed, being frequent in some sections and rare or absent in others; very small bodies are difficult to detect; chrysotile fibres frequently disappear from the lung tissue; there are individual differences in the tendency to form asbestos bodies, etc. Despite such limitations, asbestos bodies were found on routine lung sections in about 1/4 of the men resident in the Monfalcone area. Some of the above difficulties encountered in detecting asbestos bodies, may be surmounted by using isolation and counting of asbestos bodies after chemical digestion of the lung tissue. Countings of the bodies have been performed in a consistent portion of the present cases. More precise methods include the counting of the asbestos fibres and the identification of such fibres. This last point is of particular

relevance, since the old question of the danger related to the chrysotile, continues to be discussed^{14–17}.

The identification of the type of asbestos has been performed only in a very limited sample of the present series and the results have previously been published¹⁸. The analysis conducted on lung tissue, mediastinal lymph nodes, and pleural plaques of people formerly shipyard workers, showed the presence of different varieties of asbestos. Interestingly, while amphyboles were the most prevalent fibres in lung, chrysotile was the most prevalent fibre in the pleura¹⁸. Similar results on this different tropism of amphyboles and chrysotile have been obtained in other laboratories^{19, 20}.

Pleural plaque has for longtime considered as late sequelae of tuberculosis. In the early 1960's, the idea emerged with difficulty that pleural plaque is the effect of an exposure to asbestos²¹. A number of studies conducted in different settings confirmed the relationship asbestos-pleural plaque^{12, 22, 23}.

It is relevant that pleural plaque is not only a marker of asbestos exposure, but also an indicator of the exposure intensity¹². In addition, pleural plaque is a marker by far more sensitive than the presence of asbestos bodies in routine lung sections. This clearly emerges from Table 6.

In the present study the prevalence of pleural plaques was very high among men resident in the Monfalcone district. The male subjects resident in the surrounding area showed a prevalence by far lower. However, such a population of the adjacent area may only partly be considered as a referent population. In fact, a part of the Monfalcone shipyard workers came, especially in the past, also from the surrounding area. A better term of comparison may be found in Gorizia, a town distant 25 km from Monfalcone and with a relatively small number of industrial installations. In a series of 100 consecutive necropsies examined at the Hospital of Gorizia in 1994, pleural plaques were observed in 19.6% among men, and in 5.1% among women²⁴. Moreover, some men with plaques of the Gorizia series had histories of working in the Monfalcone shipyards.

The figures found in the Monfalcone area appear very high, even when compared with those found in other highly industrialized areas of northern Italy. A series of 100 necropsies were examined in the Venice area in 1992²⁵. Such area is characterized by a high concentration of industries, including chemical, machinery, metallurgical. Pleural plaques were found in 37% of men, and in 6% of women. Isolation of lung asbestos bodies showed relatively low amounts of bodies (below 1,000 per gram of dried tissue) in all women, and in 94% of men. In northwestern Italy, a study conducted in Turin on 1,019 necropsies performed in

the period September 1977–May 1979, showed pleural plaques in 24.5% among men, and in 7% among women²⁶⁾. In Turin the highest prevalence of pleural plaques, namely 37.7%, was observed among men aged 60–69 years.

When the data collected on pleural plaques, lung asbestos bodies, and on occupational histories, are considered as a whole, it emerges that the high degree of asbestos exposure in the Monfalcone area, has to be attributed mainly to the shipbuilding activity. In fact, although asbestos exposure has involved different occupational categories in the Monfalcone area, marked differences exist from one category to another in terms of exposure intensity. These differences mainly emerge, when some parameters are considered, such as the prevalences of asbestos bodies in routine lung sections, the prevalences of the complex moderate-large plaques, and the prevalences of large amounts of asbestos bodies (10,000 or more per gram) in digested lung tissue. These data clearly indicate that an important gradient existed in the past between asbestos exposure occurred in the shipbuilding, and that occurred in many other industrial activities. The present findings also indicate that asbestos exposure in Monfalcone did not remain confined to various workplaces; on the contrary the family members of the shipyard workers were involved at relevant degrees throughout the work clothes polluted by asbestos dust. The possibility that an important environmental exposure to asbestos, different from the domestic one, has occurred, is suggested by some cases; this point however requires further investigation.

The severity of the asbestos exposure is not an unexpected finding in a shipyard area. The relationship between asbestos exposure and shipbuilding activity is well known. Such relationship was firstly recognized some 40 years ago. In 1958, McCaughey described a group of pleural mesotheliomas diagnosed in Belfast, Northern Ireland²⁷⁾. In the original description, no attention had been devoted to the occupational history of these patients. However, few years later, it was ascertained that a consistent portion of the Belfast cases were represented by shipyard workers^{28, 29)}. Subsequently, clusters of asbestos-related mesotheliomas were reported from many coastal areas with shipyards, and the relationship mesothelioma-shipbuilding was recognized as one of the most typical facts in the mesothelioma epidemiology^{7, 30–32)}. The relevance of asbestos-related pathology among shipyard workers has recently been emphasized by a study conducted in Japan³³⁾. In a group of 72 shipyard workers examined at necropsy, 86% showed asbestos-related conditions, including pulmonary asbestosis, pleural plaques, lung cancer, and malignant pleural mesothelioma.

What are the implications of the present findings in terms of cancer risk for the population of the Monfalcone area? Studies performed during the last 20 years showed that the incidence of malignant mesothelioma in Monfalcone was among the highest in the world^{32, 34)}. As far as lung carcinoma is concerned, a recent analysis of 414 cases, investigated at necropsy in Monfalcone, showed that about 60% of the cases had to be attributed to asbestos¹¹⁾. In addition, studies conducted at our laboratory, indicate that pleural plaque may be considered as a risk indicator for asbestos-related mesothelioma of the pleura²²⁾ as well as for asbestos-related carcinoma of the lung³⁵⁾. The risk progressively increases by passing from small to moderate and from moderate to large plaques. This suggests that a population showing so high prevalences of moderate and large pleural plaques such those observed in the present study, is at high risk of pleural and pulmonary cancer.

Of the two markers of asbestos exposure investigated in the present study, pleural plaque appears the more sensitive one. Pleural plaque is also a parameter more easy to investigate *in vivo*. Asbestos bodies may be detected in sputum, but only when the amount of asbestos is very high. On the contrary, pleural plaques, especially when moderate or large in size, are easy to reveal by imaging techniques. The detection of pleural plaques may then represent a relevant method in screening people with not trivial exposure to asbestos and at risk for asbestos-related cancer²²⁾.

Asbestos exposure has been reduced or stopped in many shipyards throughout the world. However, in the shipyard areas, large numbers of persons, severely exposed to asbestos in the past, remain at high risk for asbestos disease. At present the possibilities of neutralizing the asbestos effects in such population are very scarce. Some studies suggest that diets rich in vegetables and fruits could protect against the development of mesothelioma^{36, 37)}. However, the evidence is limited, and further efforts are necessary to prevent asbestos disease among shipyard workers.

References

- 1) Hillerdal G (1999) Mesothelioma: cases associated with non-occupational and low dose exposures. *Occup Environ Med* **56**, 505–13.
- 2) Bianchi C, Brollo A, Ramani L (1999) The epidemic of mesothelioma in Europe. In: *Challenges to Epidemiology in Changing Europe, Proceedings of the Conference, Krakow July 2–3 1999*, eds. by Jedrychowski W, Vena J, Maugeri U, 57–63, Polish Society for Environmental Epidemiology, Krakow, Poland.

- 3) Giarelli L, Bianchi C (2000) Geography of mesothelioma: expected findings and paradoxes. *Eur J Oncol*, in press.
- 4) Huncharek M (1992) Changing risk groups for malignant mesothelioma. *Cancer* **69**, 2704–11.
- 5) Berry M (1997) Mesothelioma incidence and community asbestos exposure. *Environ Res* **75**, 34–40.
- 6) Magnani C, Ivaldi C, Botta M, Terracini B (1997) Pleural malignant mesothelioma and environmental asbestos-exposure in Casale Monferrato, Piedmont. Preliminary analysis of a case control study. *Med Lav* **88**, 302–9.
- 7) Bianchi C, Brollo A, Ramani L, Zuch C, Grandi G, Giarelli L (1998) Malignant pleural mesothelioma in the Trieste-Monfalcone area, Italy: a study of 430 cases. In: *Advances in the prevention of occupational respiratory diseases*, eds. by Chiyotani K, Hosoda Y, Aizawa Y, 295–98, Elsevier Science, Amsterdam, The Netherlands.
- 8) Peto J, Decarli A, La Vecchia C, Negri E (1999) The European mesothelioma epidemic. *Br J Cancer* **79**, 666–72.
- 9) Gennaro V, Finkelstein MM, Ceppi M, Fontana V, Montanaro F, Perrotta A, Puntoni R, Silvano S (2000) Mesothelioma and lung tumors attributable to asbestos among petroleum workers. *Am J Ind Med* **37**, 275–82.
- 10) Magnani C, Leporati M (1998) Mortality from lung cancer and population risk attributable to asbestos in an asbestos cement manufacturing town in Italy. *Occup Environ Med* **55**, 111–14.
- 11) Bianchi C, Brollo A, Ramani L, Zuch C (1999) Asbestos exposure in lung carcinoma: a necropsy-based study of 414 cases. *Am J Ind Med* **36**, 360–4.
- 12) Bianchi C, Brollo A, Ramani L, Berté R (1991) Exposure to asbestos in Monfalcone, Italy. A necropsy-based study. In: *Autopsy in epidemiology and medical research*, eds by Riboli E, Delendi N, 127–40, IARC, Lyon, France.
- 13) Smith N J, Naylor B (1972) A method for extracting ferruginous bodies from sputum and pulmonary tissue. *Am J Clin Pathol* **58**, 250–4.
- 14) Landrigan PJ, Nicholson WJ, Suzuki Y, Ladou J (1999) The hazards of chrysotile asbestos: a critical review. *Ind Health* **37**, 271–80.
- 15) Mc Donald JC, Mc Donald AD, Hughes JM (1999) Chrysotile, tremolite and fibrogenicity. *Ann Occup Hyg* **43**, 439–42.
- 16) Howie RM (1999) Minimising health hazards associated with derogated products and in-situ materials containing chrysotile contaminated with amphibole asbestos fibres. *Ann Occup Hyg* **43**, 493–6.
- 17) Addison J (1999) Minimising the health hazards associated with derogated products containing chrysotile asbestos. *Ann Occup Hyg* **43**, 496–8.
- 18) Dodson RF, Williams MG, Corn CJ, Brollo A, Bianchi C (1990) Asbestos content of lung tissue, lymph nodes, and pleural plaques from former shipyard workers. *Am Rev Respir Dis* **142**, 843–7.
- 19) Sébastien P, Janson X, Gaudichet A, Hirsch A, Bignon J (1980) Asbestos retention in human respiratory tissues: comparative measurements in lung parenchyma and in parietal pleura. In: *Biological effects of mineral fibres*, eds by Wagner J C, 237–46, IARC, Lyon, France.
- 20) Suzuki Y, Yuen S, Ashley R, Calderaro A (1998) Asbestos fibers and human malignant mesothelioma. In: *Advances in the prevention of occupational respiratory diseases*, eds by Chiyotani K, Hosoda Y, Aizawa Y, 709–13, Elsevier Science, Amsterdam, The Netherlands.
- 21) Hourihane DOB, Lessof L, Richardson PC (1966) Hyaline and calcified pleural plaques as an index of exposure to asbestos. A study of radiological and pathological features of 100 cases with a consideration of epidemiology. *Br Med J* **1**, 1069–74.
- 22) Bianchi C, Brollo A, Ramani L, Zuch C (1997) Pleural plaques as risk indicators for malignant pleural mesothelioma: a necropsy-based study. *Am J Ind Med* **32**, 445–9.
- 23) Hillerdal G (1997) Pleural plaques: incidence and epidemiology, exposed workers and the general population. A review. *Indoor Built Environ* **6**, 86–95.
- 24) Bianchi C, Rizzi C, Valantig A, Colonna M (1995) Placche ialine della pleura nell'area di Gorizia (abstract). *Pathologica* **87**, 428.
- 25) Bianchi C, Brollo A, Ramani L, Zuch C, Valsecchi M, Civelli M, Murer B (1997) Asbestos exposure in the Venice area. *Riv Med Friuli* **3**, 15–9.
- 26) Andron A, Colombo A, Dacorsi M, Mollo F (1982) Pleural plaques at autopsy in Turin. A study on 1,019 adult subjects. *Eur J Respir Dis* **63**, 107–12.
- 27) Mc Caughey WTE (1958) Primary tumours of the pleura. *J Path Bact* **76**, 517–29.
- 28) Mc Caughey WTE, Wade OL, Elmes PC (1962) Exposure to asbestos dust and diffuse pleural mesotheliomas. *Br Med J* **2**, 1397.
- 29) Elmes PC, Mc Caughey WTE, Wade OL (1965) Diffuse mesothelioma of the pleura and asbestos. *Br Med J* **1**, 350–3.

- 30) Mc Donald JC, Mc Donald AD (1977) Epidemiology of mesothelioma from estimated incidence. *Prev Med* **6**, 426–46.
- 31) Giarelli L, Bianchi C, Grandi G (1992) Malignant mesothelioma of the pleura in Trieste, Italy. *Am J Ind Med* **22**, 521–30.
- 32) Bianchi C, Brollo A, Ramani L, Zuch C (1993) Asbestos-related mesothelioma in Monfalcone, Italy. *Am J Ind Med* **24**, 149–60.
- 33) Natori Y, Ishiwata H, Akabane H, Miura H, Yuji K, Kurumatani N (1998) The relationship between shipyard works, asbestos-associated pathological findings and number of asbestos bodies in autopsy lung. In: *Advances in the prevention of occupational respiratory diseases*, eds. by Chiyotani K, Hosoda Y, Aizawa Y, 709–13, Elsevier Science, Amsterdam, The Netherlands.
- 34) Bianchi C, Brollo A, Ramani L, Zuch C (1998) Malignant mesothelioma of the pleura in Monfalcone, Italy: trend of an epidemic. In: *17th International Cancer Congress*, eds. by Moraes M, Brentani R, Bevilacqua R, 679–82, Monduzzi Editore, Bologna, Italy.
- 35) Bianchi C, Brollo A, Ramani L, Zuch C (1996) Placche ialine della pleura: indicatori di rischio per carcinoma del polmone e mesotelioma maligno della pleura (abstract). *Pathologica* **88**, 395.
- 36) Schiffman MH, Pickle LW, Fontham E, Zahm SH, Falk R, Mele J, Correa P, Fraumeni JF Jr (1988) Case-control study of diet and mesothelioma in Louisiana. *Cancer Res* **48**, 2911–5.
- 37) Muscat JE, Huncharek M (1996) Dietary intake and risk of malignant mesothelioma. *Br J Cancer* **73**, 1122–5.