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Radiological Evidence of Asbestos Disease Among Ship Repair Workers

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Asbestos materials are now infrequently used in new ship construction. However, significant amounts were used in vessels constructed before 1975. As a consequence, for the next 30 or more years, the potential for asbestos exposure in the repair of such vessels will remain.

We studied 286 workers who were 20 or more years from onset of employment in ship repair work. Eighty-six percent had radiological evidence of asbestosis, and five instances of previously undiagnosed lung cancer were found. This suggests that unless industrial hygiene precautions are taken in the future repair of vessels that have been built with asbestos, we will add additional decades to the legacy we already face as the result of uncontrolled shipyard exposures of the past.

Key words: ship repair, asbestos, asbestosis, pleural fibrosis

INTRODUCTION

The sharp focus attracted to asbestos hazards in shipyards by Harries [1] and Stumphius [2] in 1968 has proved to be well justified. Not only has mesothelioma been widely reported [3] but also lung cancer [4] and asbestosis [5–7] have been similarly identified in shipyard workers. X-ray abnormalities, particularly, have been commonly found among current and past workers engaged largely in new ship construction. The prevalences among workers more than ten years from onset of shipyard work in three recent studies were 48% (15+ years) [5], 31% (12–27 years) [6], and 59% (10+ years) [7]. With this and other evidence of disease, the use of asbestos materials during new ship construction has been largely abandoned in shipyards, at least in the United States [8]. While we are likely to have an unhappy legacy of disease from past exposures, it may be hoped that this will be limited to the next three to five decades [9].

But there is another legacy; the asbestos in place within ships constructed during these past years, now afloat, will be subject to repair, maintenance and, ultimately, ship breaking. Ship repair and maintenance is a large and important industry in the United States. In 1974, the U.S. Maritime Administration held master repair contracts with 77 ship repair facilities, including 36 on the East Coast, 18 along the Gulf Coast, 22 on the West Coast, and one on the Great Lakes [10]. In 1978 there were approximately 241,000

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employees in the U.S. shipbuilding and ship repair industry, 70% working in commercial yards [11]. The question naturally arises whether ship repair work, as distinct from new ship construction, carries a similar or even greater risk of asbestos-associated disease. If so, improperly controlled asbestos repair work may be the source of new shipyard-related disease in the future, adding additional decades to the years of difficulties already anticipated.

PRESENT INVESTIGATION

We have had the opportunity of studying the health status of long-term employees of a shipyard that limited its work to ship repair. The yard employing the workers investigated by us was given its present configuration and tasks in the mid-1930s [12], and the workers there have been represented by their current union from about the same time. All active members on the union's rolls on January 1, 1979, were listed by seniority. From those 20 or more years from onset of employment in the yard, we sought to invite all burners, welders, and painters for examination, as well as every second or third individual in each of the other departments. Preference was given to the selection of burners and welders because of a desire to investigate exposure to metal fumes during welding and cutting operations, and to painters because of their exposure to solvents. The selection in other departments attempted to achieve approximately equal representation by trade. There were a number of departments with only a few workers eligible for inclusion in the study, and as findings in such groups would be difficult to evaluate, men in these departments were not invited (time keeping, fire department, fabrication, blacksmith, coppersmith, tool room, transportation, powerhouse, and dock). Twenty-one eligible individuals worked in these departments, constituting 6% of the possible invitees. All the considerations resulted in a total of 179 of 329 eligible currently employed workers being invited.

Retired members, 20 or more years from onset, were then listed alphabetically. All painters and welders were scheduled, followed by every second retiree in the same departments, as utilized for active employees. With consideration of geographical proximity (within 250 miles), 284 of 490 eligible retired members were invited. The total number of men scheduled was 463 (Table I). It was our intention to seek both active and retired members of the local, since this would permit access to men with long duration from onset of employment, even if currently retired, to facilitate observation of the longer term effects of shipyard employment.

The examination were accomplished February 24–27, 1979. The participation rate among those invited was gratifyingly high, considering that many of the men, especially those who had retired, lived considerable distances from the examination site and that the city and surrounding areas had just suffered their severest snow storm in decades, with obstruction and dislocation of vehicular traffic over a wide area. One hundred thirty-nine of the 179 actively employed and 147 of the retired men who were invited, came for examination. Table I records the number of men in each department who were invited and participated. The distributions in age and time from onset of shipyard employment of those examined are shown in Table II. Most participants were between 50 and 69 years of age and had begun work 30 to 39 years previously.

Examination included lifetime occupational and medical histories, with smoking habits, full physical examination, biochemical and hematological studies, full size (14" X 17") chest films, pulmonary function tests, including ventilation and diffusion

TABLE I. Participation in a Health Survey of Shipyard Workers

Department	Eligible men[a]			Participated		
	Active	Retired	Invited[b]	Active	Retired	Total
Burners, welders	79	94	173	59	49	108
Fitters	51	84	73	18	21	39
Pipe shop	17	26	28	7	4	11
Outside machine shop	29	42	16	5	8	13
Riggers	24	49	40	5	19	24
Carpenters	4	27	16	1	10	11
Painters	22	27	49	18	9	27
Laborers	31	44	20	6	7	13
Equipment operators	15	15	13	8	4	12
Inside machinists, boiler, electric and sheet metal shops and maintenance	57	82	35	12	16	28
Total	329	490	463	139	147	286

[a]All more than 20 years from onset of shipyard employment.
[b]In addition, invitations were not provided to 21 active and 65 retired men in the following trades: time keepers, firemen, fabrication shop, blacksmiths, coppersmiths, joiners, toolroom, transportation, powerhouse, dock department.

TABLE II. The Distribution of Age and Years Since Onset of Shipyard Work for 286 Health Survey Participants

Age	Years since onset of shipyard work				
	20–29	30–39	40–49	50+	Totals
>50	8	2			10
50–59	22	65	7		94
60–69	4	101	35	5	145
70+	1	23	6	7	37
Totals	35	191	48	12	286

studies, as well as ear oximetry, and neurobehavioral examinations for solvent toxicity. These multifaceted studies of the effect of shipyard exposures on pulmonary and neurobehavioral functions will each be separately reported as will five cases of previously undiagnosed bronchogenic carcinoma found during the examinations. Here we describe the radiological manifestations of effects from dust exposure in ship repair work.

RESULTS

Radiological Evidence of Asbestosis

Chest films were read by a panel of five experienced physicians using the ILO U/C Classification of Radiographs of Pneumoconioses [13], without knowledge of the clinical, work history, or other characterization of the individual. Consensus readings were recorded. Of the 286 individuals examined in this survey, readable x-rays were obtained for 285.

One individual failed to have an x-ray taken and one had severe sarcoidosis which precluded obtaining information on any pneumoconiosis that might be present. Thus, 284 x-rays were available for analysis.

The distribution of abnormalities, according to the full ILO/UC classification of pneumoconioses for small opacities, is shown in Table III. No large opacities were observed. Radiological evidence of pneumoconiosis was found in 86.3% of the workers examined. Thirty-nine of 284 (13.7%) men had normal films. Parenchymal fibrosis alone was found in 90 cases, and 21 had only pleural abnormalities. One hundred thirty-four had both parenchymal and pleural changes. These parenchymal changes were largely classified as small irregular opacities (s) characteristic of asbestos exposure. A small percentage of the x-rays (6.3%) also showed small rounded opacities characteristic of other dust exposures (see below). The abnormalities were generally unequivocal. One hundred fourteen, 40.1% of the entire group, were of category 1/1. More extensive abnormalities were also common, especially among retirees. This would reflect the longer time from onset of exposure among these individuals. The proportion of individuals with abnormal films increased with longer duration from onset of shipyard employment. Among 37 men who were 20 to 29 years from onset, 25 (67.6%) had abnormal films. Of 192 who were 30 to 39 years from onset, 170 (88.5%) were abnormal. Of 55 men 40 or more years from onset of shipyard employment, approximately the same proportion were abnormal (50 men; 90.9%) (Table IVa).

Since shipyard workers sometimes work in more than one yard during their working lifetimes, and since work in other yards, with new ship construction, might have had a different effect than that associated solely with ship repair and ship maintenance, we have analyzed the x-ray findings for the 185 men who had been engaged only in shipyard work in the ship repair yard under study for their working lifetimes (Table IVb). The results were almost identical, in terms of proportions of men with the various radiological abnormalities. Further, these findings were present among workers in each of the trades (Table V), with no department free from risk.

Rales

Analysis of the findings on physical examination suggests that radiological changes are a far more sensitive index of pulmonary changes than rales on auscultation. In contrast to 86.3% with abnormal films, only 11.0% had crepitant rales at the time of examination. The prevalence varied from 6.7% among those with no radiological evidence of parenchymal fibrosis to 22.9% with category 2 or 3 pulmonary fibrosis (Table VI).

Influence of Cigarette Smoking

Evidence is available in prospective cohort studies [14–16] that cigarette smoking increases the risk of death from asbestosis among asbestos workers, and other data suggest that it may increase the prevalence of x-ray abnormalities [17]. It was therefore of interest to investigate whether the prevalence of radiographic changes varied in relation to the smoking habits of the workers. In the group studied here a history of cigarette smoking did not make an appreciable difference in the prevalence of x-ray abnormalities (Table VII); 17.3% of 110 current smokers had normal films, as did 9.3% of 118 ex-smokers; 16.1% of workers without history of cigarette smoking also showed no evidence of asbestosis. The same general observations were as true for pleural as for parenchymal abnormalities. Seventy of 228 (30.7%) with a history of cigarette smoking showed

TABLE III. The Distribution of Small Opacities Among 284 Shipyard Workers

ILO/UC classification small opacities[a] (combined perfusion)	Number within category					
	Active			Retired		
	Normal pleura	Abnormal pleura	Total	Normal pleura	Abnormal pleura	Total
0/–	0	0	0	0	0	0
0/0	9	2	11	3	3	6
0/1	12	10	22	15	6	21
1/0	10	13	23	11	12	23
1/1	33	31	64	16	34	50
1/2	5	3	8	2	6	8
2/1	3	1	4	3	10	13
2/2	2	3	5	4	16	20
2/3	0	0	0	0	1	1
3/2	0	0	0	2	0	2
3/3	1	1	2	1	0	1
3/4	0	0	0	0	0	0
	75	64	139	57	88	145

[a]No large rounded opacities were observed.

parenchymal changes alone, against 20 of 56 non-smokers (35.7%). Similarly, 110 of the 228 (48.2%) current and former smokers had both pleural and parenchymal change, compared to 24 of the 56 (42.8%) who had not smoked.

Age

It is difficult to separate any influence of attained age from the much more powerful influence of latency from onset of exposure (Table IVa and b), but we analyzed our data to determine whether an effect could nevertheless be present. We found no convincing evidence of an influence of increasing age, although as expected, abnormalities increased over time, concomitant with age (Table VIII). Eleven of 92 (12.0%) in the age category 50–59 were normal, as were 20 of 145 (13.8%) from 60–69 and 4 of 37 (10.8%) for those 70 and over. The strong correlation between age and onset of exposure (Table II) and general high prevalence of abnormality precluded any multivariate analysis to identify age effects.

Occupational Asbestos Exposure

Previous studies of shipyard employees have described widespread dissemination of asbestos fibers during routine installation and maintenance of thermal insulation materials aboard ship. In addition to the direct exposure of the workmen involved, indirect exposure can occur to men of many crafts working nearby. From the occupational histories obtained in this survey, it was found that during previous years the opportunity for asbestos exposure to virtually all of the men examined was great. Although only three of the 284 men had worked regularly as insulators, approximately half of the remaining individuals were employed in crafts that occasionally work directly with asbestos material. These included welders, pipefitters, and boilermakers, who occasionally were

TABLE IVa. Radiological Abnormalities* Among 284 Ship Repair Workers in Relation to Years From Onset of Shipyard Employment

Duration from onset of exposure (years)	Total number examined	Normal x-ray	No pleural fibrosis or calcification: Extent of parenchymal fibrosis 1	2	3	Total	Pleural fibrosis and/or calcification present: Extent of parenchymal fibrosis 0	1	2	3	Total	Any abnormality
20–29	37	12	11	0	0	11	3	11	0	0	14	25
	13.0%	32.4%	29.7%	0%	0%	29.7%	8.1%	29.7%	0%	0%	37.8%	67.6%
30–39	192	22	55	12	1	68	16	61	22	3	102	170
	67.6%	11.5%	28.6%	6.3%	0.5%	35.4%	8.3%	31.7%	11.5%	1.6%	53.1%	88.5%
40+	55	5	11	0	0	11	2	27	9	1	39	50
	19.4%	9.1%	20.0%	0%	0%	20.0%	3.6%	49.1%	16.4%	1.8%	70.9%	90.9%
Total	284	39	77	12	1	90	21	99	31	4	155	245
	100.%%	13.7%	27.1%	4.2%	0.4%	31.7%	7.4%	34.9%	10.9%	1.4%	54.6%	86.3%

*International Classification of Radiographs of Pneumoconiosis, ILO U/C (0 = 0/0, 0/1; 1 = 1/0, 1/1, 1/2; 2 = 2/1, 2/2, 2/3; 3 = 3/2, 3/3, 3/4. Pleural abnormalities include all recorded grades).

TABLE IVb. Radiological Abnormalities* Among 185 Ship Repair Workers With Employment Limited to One Ship Repair Yard in Relation to Duration From Onset of Shipyard Employment

Duration from onset of exposure (years)	Total number examined	Normal x-ray	No pleural fibrosis or calcification: Extent of parenchymal fibrosis 1	2	3	Total	Pleural fibrosis and/or calcification present: Extent of parenchymal fibrosis 0	1	2	3	Total	Any abnormality
20–29	28	9	7	0	0	7	3	9	0	0	12	19
	15.1%	32.1%	25.0%	0%	0%	25.0%	10.1%	32.1%	0%	0%	42.9%	67.8%
30–39	116	13	30	7	1	38	10	37	16	2	65	103
	62.7%	11.2%	25.8%	6.0%	0.9%	32.8%	8.6%	32.9%	13.8%	1.7%	56.0%	88.7%
40+	41	5	7	0	0	7	2	21	5	1	29	36
	22.1%	12.2%	17.1%	0%	0%	17.1%	4.9%	51.2%	12.2%	2.4%	70.7%	87.8%
Total	185	27	44	7	1	52	15	67	21	3	106	158
	100.0%	14.6%	23.7%	3.8%	0.5%	28.7%	8.1%	36.2%	11.4%	1.6%	57.3%	85.4%

*International Classification of Radiographs of Pneumoconiosis, ILO U/C (0 = 0/0, 0/1; 1 = 1/0, 1/1, 1/2; 2 = 2/1, 2/2, 2/3; 3 = 3/2, 3/3, 3/4. Pleural abnormalities include all recorded grades).

TABLE V. Radiological Abnormalities* Among 284 Ship Repair Workers 20 or More Years From Onset of Shipyard Employment

Department	Total number examined	Normal x-ray	No pleural fibrosis or calcification: Extent of parenchymal fibrosis 1	2	3	Total	Pleural fibrosis and/or calcification present: Extent of parenchymal fibrosis 0	1	2	3	Total
Burners, welders	107	10	34	9	0	43	9	31	14	0	54
Fitters	39	6	10	0	0	10	2	20	1	0	23
Pipe shop	10	1	4	0	1	5	0	2	2	0	4
Outside machine shop	13	1	0	0	0	0	1	8	2	1	12
Riggers	24	1	6	0	0	6	2	11	3	1	17
Carpenters	11	0	4	0	0	4	0	4	2	1	7
Painters	27	6	5	1	0	6	2	10	2	1	15
Laborers	13	3	3	1	0	4	3	2	1	0	6
Equipment operators	12	4	3	0	0	3	0	4	1	0	5
Inside machinists, electric and sheet metal shops	18	5	5	1	0	6	1	5	1	0	7
Boiler shop and maintenance	10	2	3	0	0	3	1	2		0	5
Total	284	39	77	12	1	90	21	99	31	4	155

*International Classification of Radiographs of Pneumoconiosis, ILO U/C (0 = 0/0, 0/1; 1 = 1/0, 1/1, 1/2; 2 = 2/1, 2/2, 2/3; 3 = 3/2, 3/3, 3/4. Pleural abnormalities include all recorded grades).

TABLE VI. Presence or Absence of Rales Among Ship Repair Workers

Extent of parenchymal fibrosis	Rales	No pleural abnormality	Pleural fibrosis and/or calcification	Rales	
				No.	%
0	0	35	21	56	93.3
	+	4	0	4	6.7
1	0	68	90	158	90.8
	+	7	9	16	9.2
2	0	10	25	35	81.4
	+	2	6	8	18.6
3	0	0	2	2	40.0
	+	1	2	3	60.0
Total	0	113	138	251	89.0
	+	14	17	31	11.0
		127	155	282	100.0

TABLE VII. Roentgenographic Abnormalities Among 284 Ship Repair Workers in Relation to History of Cigarette Smoking

Smoking status at time of examination	Total category	Roentgenographic appearance							
		Normal		Parenchymal abnormality only		Pleural abnormality only		Both parenchymal and pleural abnormality	
		No.	%	No.	%	No	%	No.	%
Current smoking	110	19	17.3	34	30.9	10	9.1	47	42.7
Ex-smoking > 5 years	91	7	7.7	30	33.0	8	8.8	48	52.7
Ex-smoking < 5 years	27	4	14.8	6	22.2	2	7.4	15	55.6
All ex-smoking	118	11	9.3	36	30.5	10	8.5	63	53.4
No history of cigarette smoking	56	9	16.1	20	35.7	3	5.4	24	42.8
	284	39	13.7	90	31.7	21	7.4	134	47.2

required to remove small sections of asbestos material from high temperature lines and equipment prior to repair work; carpenters, who cut asbestos cement panels; burners and welders, who occasionally used woven asbestos blankets for heat shielding; and laborers, who cleaned up asbestos debris. Indirect exposures additionally were common among men of the above trades, as well as among riggers, shipfitters, machinists, painters, and electricians, among others working abroad ship during and after asbestos installation and repair. Even men assigned to yard shops (machine, electrical, sheet metal, etc) go aboard ship at times and may have been previously assigned to shipboard work. Furthermore, asbestos exposures within the shops could also occur through the dissemination of the asbestos fibers from elsewhere in the yard.

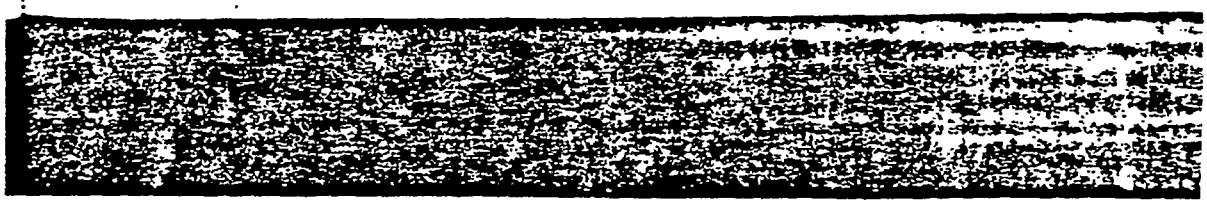

TABLE VIII. Roentgenographic Abnormalities Among 284 Ship Repair Workers in Relation to Attained Age

Age at time of examination	Total in age category	Normal		Parenchymal abnormalities only		Pleural abnormalities only		Both pleural and parenchymal abnormalities	
		No.	%	No.	%	No.	%	No.	%
40–49	10	4[a]	40	3	30	0	0	3	30
50–59	92	11	12.0	38	41.3	8	8.7	35	38.0
60–69	145	20	13.8	39	26.9	11	7.6	75	51.7
70–79	37	4[b]	10.8	10	27.0	2	5.4	21[b]	56.8
	284	39[c]	13.7	90	31.7	21	7.4	134	47.2

[a]Includes one worker younger than 40.
[b]Includes one worker older than 79.
[c]Includes two workers older than 79.

Siderosis and Silicosis

In view of the large amount of welding in ship repair and the possibility that roentgenographic changes might, to a considerable extent, reflect benign pulmonary siderosis rather than asbestosis, we have analyzed the results obtained according to whether an individual was or was not engaged regularly in welding and burning work. Table IX shows this comparison. The results indicate that welding and metal cutting were associated with a greater prevalence of small rounded opacities, 10.3% of welders and burners having such changes compared to 4.0% among men in other trades. However, of the 18 individuals with small rounded opacities present, the combined profusion major category (0, 1, 2, 3) differed in only once case from that determined by an analysis of small irregular opacities only. Furthermore, the prevalence of all small opacities among welders and burners was virtually identical to that of all other workers.

Similarly, the effects of exposure to silica dust among shipyard trades was investigated. From the early 1950s to the late 1960s sandblasting, using silica, was used for the removal of rust, scale, and paint from metal. Most commonly, such work was done by laborers, who used air supplied respirators. Small rounded opacities, however, were not seen among any of the 13 laborers examined, and the low prevalence of such abnormalities throughout the study group suggests that silica exposures were not of serious consequence during previous years.

Other Dust Exposures

Careful occupational histories revealed that 51 individuals had had other dust exposures, largely to hard and soft coal dust, or were exposed to asbestos in other than shipyard circumstances. These exposure are listed in Table X. In nine cases the dust in question (cotton, cement, grain) was unlikely to produce lung scarring and affect the x-ray reading. Twenty were exposed to soft coal dust during mining, delivery, or work stoking fires. Dust exposures in these activities also generally do not lead to small irregular opacities. Six may have been exposed to silica, either directly (grinding metal or stone quarrying) or during hard coal mining, but only one demonstrated the presence of small

TABLE IX. Number and Percentage of Small Opacities Among Welders and Burners Compared to Men in Other Trades

Employment	Number of men	Number and percentage of x-rays showing rounded opacities		Number and percentage of x-rays showing irregular opacities	
Welders/burners	107	11	(10.4%)	96	(89.7%)
Other trades	177	7	(4.0%)	148	(84.1%)
Total	284	18	(6.3%)	244	(85.9%)

TABLE X. Exposure to Dust in Other Than Shipyard Work

Other dust exposure	Number of individuals	Average duration of work (years)	Number with abnormal x-rays
Cotton	6	5.8	3
Cement	2	4.0	1
Grain	1	6.0	1
Silica	2	4.0	1
Hard coal mining	4	5.2	3
Soft coal mining	13	4.8	11
Coal delivery/firemen	7	4.6	6
Asbestos	16	3.8	16
U.S. Navy	8	4.7	8
Garage work	4	2.2	4
Refinery employment	1	4.0	1
Paint mixing	1	5.0	1
Occasional insulation work	1	4.0	1
Loading shingles	1	0.5	1

rounded opacities on x-ray. Of the 16 asbestos exposures in other than shipyard work, only two appeared to be of an intensity equal to that experienced during ship repair. These included an individual who occasionally did insulation work for four years and a paint mixer who at times added asbestos to formulations. Eight of the others were Navy personnel aboard ships (five on deck and three in the engine room), four worked as garage mechanics and would have repaired brakes about once a week, one worked in a refinery, and one loaded trucks with asbestos shingles for less than one year. Overall 83.3% of those with other dust exposures had abnormal x-rays compared with 86.2% of the entire group. Thus, exposures to dusts in other than shipyard employment, while possibly contributing to the prevalence and degree of x-ray abnormalities seen here, did not influence the major findings obtained.

Previous X-Ray Evidence of Disease

At the time of this survey the individuals examined were queried as to the results of previous chest x-ray examinations, which had been provided by a variety of health care

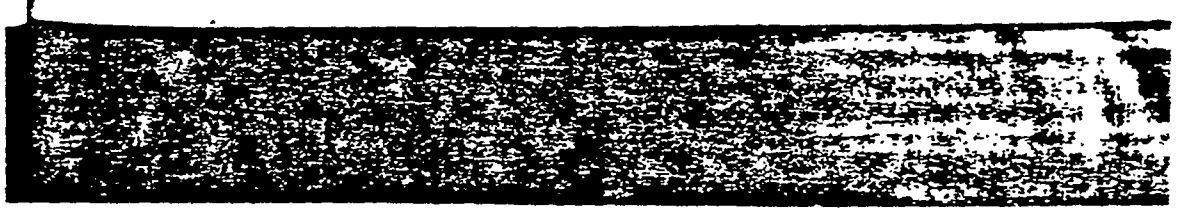

TABLE XI. Worker Understanding of Previous X-Ray Findings

X-ray reading at this examination	Worker understanding of previous x-ray			
	X-ray taken during last two years		X-ray taken more than two years before	
	"normal"	"abnormal"	"normal"	"abnormal"
Normal	15	1	5	3
1/0 1/2[a]	40	12	52	7
2/1–3/4[a]	15	11	9	3
Pleural only	2	1	9	0
	72	25	75	13

[a]Pleural abnormalities may also have been present.

facilities. Of the 282 men, 267 reported having had a previous x-ray and 185 provided information of their understanding of the results of the readings (Table XI). Of those aware of the results, 38 (20.7%) were told that abnormalities were present on their chest films. For those with x-rays taken during the previous two years this percentage was 26.6% (25 of 97). However, 57 of 81 individuals (70.0%) whose x-rays in this examination were found to be abnormal and who knew the results of an x-ray taken during the previous two years were unaware of the presence of any abnormality. This included 15 of 26 individuals with 2/1 or greater profusion of small opacities.

DISCUSSION

Widespread prevalence of radiological abnormalities has been found among ship repair workers. These are largely the small irregular parenchymal opacities and pleural changes characteristic of asbestos exposure. Ubiquitous exposure to asbestos, both direct and indirect, was reported in the occupational histories of individuals examined. Other shipyard dusts and exposures in other than shipyard employment were investigated and could not account for the abnormalities observed. Thus, given the widespread opportunities for exposure during past years, the finding of radiological abnormalities characteristic of asbestos disease is not unexpected. The finding of a greater prevalence of abnormalities than in new ship construction is worthy of note. It points to a significant legacy of disease from past activities and to the potential for a severe continuing problem in ship repair work.

With the observation that 86.3% of the men, 20 or more years from onset of ship repair work, had radiological evidence of pulmonary asbestosis, the fact that a large proportion of workers were unaware of asbestos-related abnormalities on their previous x-rays is of special concern. In some cases currently observed abnormalities may have become manifest during intervening years. However, in many cases this was unlikely. Other reasons may be misreading of the x-ray, the judgment of a physician concerning disclosure of such information, or inadequate physician–patient communication. Such findings suggest the need for an appropriate surveillance program for shipyard workers (and other asbestos-exposed workers), which will properly identify asbestos disease and provide appropriate information and counsel to the individuals affected. Knowledge of existing preliminary disease can be of aid to physicians in treating intercurrent respiratory infections and counseling concerning the special risks of cigarette smoking with asbestos exposure may provide added incentive for an individual to cease smoking [16].

The high prevalence of asbestos disease also indicates that repair work in the presence of asbestos put in place during shipbuilding can be extraordinarily hazardous. Vessels built to approximately 1975 utilized asbestos materials in their construction: "It is estimated that all vessels delivered before 1975 have extensive asbestos insulating materials aboard. Most vessels delivered between 1975 and 1978 may have asbestos in the form of insulating cement . . . . Vessels delivered in 1979–1980 and thereafter will be essentially free of asbestos insulating material" [8]. It is anticipated that vessels built with asbestos will remain afloat, with periodic repair and refitting, for the next several decades.

Risk in these vessels may not be limited to the shipyard workers called upon for their repair. Navy line personnel have been found to have radiological evidence of asbestosis and these abnormalities have also been observed among shipboard personnel in commercial vessels, as well [18]. It is not uncommon, for example, for engine room staff to rip out existing asbestos insulation to initiate necessary repairs at sea, thus lessening turn-around time in port. This can result not only in significant exposure to the men assigned to such work, but in persistent area contamination as well, with potential exposure of other ship personnel in addition: "In the course of a voyage, it is not unusual for crewmen to repair pipe, pipe flanges or valve leaks and this generally means a teardown situation. We must assume . . . asbestos insulation . . . affect not only the shipyard worker, but the crew as well" [8].

The use of asbestos in ship construction in vessels built in other countries is also of importance to shipyard workers in the United States, since these vessels may be brought to U.S. yards for repair, refitting, and ship breaking. For this reason, rigorous, uniform industrial hygiene practices should be applied to avoid asbestos exposure among ship repair workers in the future.

SUMMARY

Workers employed in ship repair, refitting, and maintenance have been found to have significant risk of asbestosis. Eighty-six percent of those with 20 or more years from onset of shipyard employment in ship repair work were found to have radiological evidence of asbestosis. Both parenchymal and pleural disease were common. These findings were also noted among 185 ship repair workers whose entire shipyard experience had been devoted to ship repair work. Further, five cases of previously undiagnosed lung cancer were found [19].

Asbestos materials are now infrequently used in new ship construction, and this will serve to sharply diminish risk of asbestos-associated disease in such work in the future. However, vessels constructed before 1975 are likely to have had significant amounts of asbestos used in their construction, and for the next 30 or more years the potential for asbestos exposure in the repair of these vessels will remain, unless appropriate industrial hygiene precautions are taken.

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