

Mesothelioma Associated with the Shipbuilding Industry in Coastal Virginia

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ABSTRACT

A case-control study was undertaken to clarify reasons for a four-fold increased incidence of mesothelioma discovered among white males in coastal Tidewater, Va., from 1972 to 1978. Sixty-one cases were identified. Interviews with next of kin revealed that the excess was linked to employment in area shipyards. Three-fourths of the cases had been employed in the shipbuilding industry, nearly all beginning employment prior to 1950. Most were career employees, but an increased risk was also found among those who worked only temporarily, mainly during World War II, and were reportedly exposed to asbestos. More of the cases than controls were pipecoverers or pipefitters, but cases were reported to work in a variety of shipyard trades. Few of the mesothelioma cases were heavy smokers, a trend that may be related in part to the competing risks for fatal diseases caused by the interactions of smoking and asbestos exposure. Information obtained by interview for five of the six white females diagnosed with mesothelioma revealed that the husbands of four had been employed in the shipbuilding industry.

INTRODUCTION

A county-by-county survey of cancer mortality in the United States from 1950 to 1969 revealed that the rates for lung cancer were unusually high among white male residents in southern coastal areas (19). Correlational studies suggested a link to the shipbuilding industry (4), and a case-control interview study of patients with lung cancer in coastal Georgia confirmed that work in shipyards during World War II was at least partly responsible for the elevated rates in that area (2). Asbestos exposures in ship construction and repair were suspected, but the actual handling of asbestos was not reported to be excessive, and the frequency of mesothelioma in coastal Georgia did not seem unusual. To further investigate these relationships, studies were initiated in Tidewater, Va., where several large shipyards operated through World War II and continue to be major employers today. Special attention was given to mesothelioma, a rare and fatal cancer that has been linked to asbestos exposures in various industries (14, 25). A multihospital survey was carried out to estimate the incidence of mesothelioma in Tidewater, and a case-control interview study was conducted to identify risk factors.

METHODS

All cases of mesothelioma among residents of Tidewater³

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³ Tidewater consists of the counties of Accomack, Gloucester, Isle of Wight,

during 1972 to 1978 were sought from the discharge diagnoses, pathology files, and tumor registries at the major hospitals in coastal Virginia. Records of the Virginia Tumor Registry were also screened, and local physicians likely to have seen patients with this disease were consulted. Paraffin blocks from surgical biopsies or postmortem examinations were sought for all cases, and new slides were prepared and reviewed by experienced pathologists of the United States Mesothelioma Panel.

Mesothelioma incidence rates were calculated for each sex, race, and age group (10-year intervals) by dividing the number of cases in each category by the appropriate population at risk. The observed numbers of cases were compared to expected numbers based on national estimates of mesothelioma incidence (12). The differences were tested for statistical significance using standard methods for Poisson variables (1).

The case-control study was limited to white males, the only group in Tidewater with elevated rates for mesothelioma. Controls consisted of 320 white male residents of Tidewater who died during 1972 to 1976 from causes other than chronic respiratory diseases and who represent the comparison group for a parallel case-control study of lung and laryngeal cancers ongoing in the same area (3). These controls were identified by random selection from mortality listings and chosen to be similar with respect to age at death and county of usual residence to the patients with lung or laryngeal cancer. Causes of death among the controls were as follows: nonrespiratory cancer, 12%; acute heart disease, 38%; chronic heart disease, 17%; cerebral vascular disease, 8%; other circulatory disease, 5%; digestive disease, 6%; pneumonia, 2%; accidents and violence, 3%; and other causes, 6%. The control group (median, 64 years) was slightly older than the mesothelioma cases (median, 60 years); therefore, the analyses for case-control differences were age adjusted.

Personal interviews of the next of kin of the deceased mesothelioma cases and controls were conducted by professional interviewers, although 4 white male cases still living were interviewed directly. A standardized questionnaire was used for both cases and controls to obtain information on the place, type, and length of employment for all jobs held for 6 months or longer. The occupational history sought the name and address of the employer, the individual's job title, duties performed, and materials handled during work. To stimulate the respondent's memory, each was asked about exposures to a variety of industries (including shipbuilding) and materials (including asbestos). Also obtained was information on smoking habits and residential history.

James City, Lancaster, Mathews, Middlesex, Nansemond, Northampton, Northumberland, Southampton, Surrey, and York and the independent cities of Chesapeake, Franklin, Hampton, Newport News, Norfolk, Portsmouth, Suffolk, Virginia Beach, and Williamsburg.

Estimates of the RR's⁴ (odds ratios and confidence intervals) of mesothelioma, adjusted for age, were calculated for exposures of interest (18, 20). RR's for employment in the shipbuilding industry were determined according to reported handling of asbestos. Shipbuilding occupation was assessed as "job longest held" (usual job), "job ever held," and according to date of initial employment in the shipyards, in order to contrast long-versus short-term employment and work started before versus work started after 1950. The RR of mesothelioma for cigarette smoking was also determined and was tested for trend according to amount usually smoked (17). Analyses of the relationship to cigarette smoking were also conducted by restricting comparisons to controls representing causes of death not known to be related to smoking. Thus, 136 controls representing cancers of the oral cavity, esophagus, pancreas, and bladder, and heart disease were excluded.

RESULTS

A total of 74 cases of mesothelioma was reported during 1972 to 1978 among Tidewater residents. There were 61 white males, 6 black males, 6 white females, and 1 black female. The annual age-adjusted incidence rate per 100,000 population among white males was 2.7, nearly 4 times higher than the national rate for males of 0.7 (12). However, the age-adjusted rates for black males (0.6), white females (0.2), and black females (0.1) were not elevated. The higher incidence among white males was evident at all ages above 40 years (Table 1). The annual rates showed little change over the 7-year study period.

The hospital records revealed 67 pleural, 5 peritoneal, and 2 pericardial mesotheliomas. Tissue specimens were obtained for 47 of the mesotheliomas among white males. For 10 cases, the pathology material was not sufficient for independent analysis. Of the remaining 37 cases 35 were either definite (32%), probable (35%), or possible (27%) mesotheliomas, while 2 (5.5%) were regarded not to be mesothelioma.

Interviews were completed for 56 of the 61 white males with mesothelioma. Of the 5 not interviewed, the next of kin could not be located (4 cases) or would not consent to interview (1 case). Of the 320 eligible controls, the next of kin of 61 had moved, could not be located, or refused interview. After the interview, 11 controls were excluded because of a history suggesting respiratory cancer, and 12 were excluded because of unsatisfactory information obtained at interview. Thus, the study group consisted of 56 mesothelioma cases and 236 controls, most of whom were longtime residents of the Tidewater area.

Shipyard employment was reported for 77% of the cases, compared to 28% of the controls. The RR (15.7) was highest among shipyard workers who were reported to have handled asbestos (Table 2). Among shipyard workers with no reported asbestos exposures, the RR (4.9) was also significantly high. Almost all (39 of 43) cases who had ever worked in the shipbuilding industry began employment prior to 1950 (most during World War II⁵), compared to 51 of the 67 controls. The

⁴ The abbreviation used is: RR, relative risk.

⁵ The distribution of cases by year of initial employment in shipbuilding was as follows: ≤ 1938 , 12; 1939 to 1945, 19; 1946 to 1949, 4; 1950 + 3; with 4 known to have worked prior to 1950 although the exact year was unspecified and 1 with unknown years of employment.

Table 1
Incidence of mesothelioma, 1972 to 1978, among white male residents of Tidewater, Va., according to age

| Age (yr) | No. of cases | No. of cases expected ^a | Incidence rate (cases/yr/10 ⁵) |
|----------|--------------|------------------------------------|--|
| <40 | 0 | 1.3 | 0.0 |
| 40-49 | 5 | 2.3 | 1.5 |
| 50-59 | 18 | 3.6 | 6.2 |
| 60-69 | 25 | 5.3 | 14.1 |
| 70+ | 13 | 3.6 | 12.5 |
| Total | 61 | 16.1 | 2.7 ^b |

^a Based on estimated national incidence rates 1970 to 1976 (from Ref. 6).

^b Age-adjusted rate using 1970 United States population as standard.

median age at first employment was 24. The median length of time between first employment and diagnosis of mesothelioma was 34 years (range, 18 to 54 years). The 3 cases beginning employment after 1949 were diagnosed at young ages (40, 40, and 58 years), respectively, 19, 21, and 18 years after initial employment.

The RR's for workers who began employment prior to 1950 were calculated according to handling of asbestos and usual industry of employment (Table 3). The RR was 18.1 for career shipyard workers who were reported to have handled asbestos. The RR's were 16.4 for those who worked temporarily, mainly during World War II, and were reportedly exposed to asbestos; and 10.3 for career shipyard workers not reported to have handled asbestos. The average number of years in the shipbuilding industry for career workers with mesothelioma was 27 years. For noncareer workers, the average was 4.7 years. Thirty of the cases were pipecoverers or pipefitters compared to only 3% of the controls. For other jobs, there were no major case-control differences, with mesothelioma cases involved in a variety of shipyard trades (Table 4).

Thirteen of the 56 mesothelioma cases were not classified as shipyard workers. In 2 of these cases, asbestos exposure was reported: one was a pipe insulator in a construction industry; and the other was a sailor who cut pipes covered with asbestos on a Navy ship. In 11 of these cases, there was no reported asbestos exposure, although the usual occupations included a ship engineman, boiler technician, Navy Captain, and captain of a commercial shipping line. In addition, one case was a pipecoverer before becoming a car salesman, and 4 men (carpenter, roofer, painter, and handyman) were associated with construction activities most of their lives. The occupations reported for the remaining 2 men did not suggest potential exposure to asbestos. Interviews were conducted for 5 of the 6 white females with mesothelioma. One was an office clerk in a shipyard, while she and 3 others were married to shipyard workers.

The RR's of mesothelioma were calculated according to the smoking categories indicated in Table 5. Using the entire control series, there was a 40% reduction in risk associated with ever smoking cigarettes and a significant trend of decreasing risk with increasing amounts of cigarettes smoked ($p < 0.01$). Using the controls with nonsmoking-related causes of death, the overall reduction was only 20%, primarily due to a deficit of heavy smokers among the cases. Only 2 of the 56 cases were reported to smoke 2 or more packs/day. The RR's associated with shipyard employment and asbestos exposure were approximately the same for smokers (of a half-pack a day or more) and non-or-light smokers.

Table 2
RR's for mesothelioma according to shipyard employment and reported asbestos exposure

| Ever-employed in shipbuilding | Reported asbestos exposure | No. of cases | No. of controls | Age-adjusted RR ^a | 95% confidence limits |
|-------------------------------|----------------------------|--------------|-----------------|------------------------------|-----------------------|
| Yes | Yes | 24 | 18 | 15.7 | 7.0-35.0 |
| | No | 19 | 49 | 4.9 | 2.3-11.1 |
| No | Yes | 2 | 13 | 1.9 | 0.4-9.9 |
| | No | 11 | 156 | 1.0 | |

^a All risks relative to the never employed in shipyard and no asbestos exposure category.

Table 3
RR's for mesothelioma among men first employed in shipyard work prior to 1950 according to reported asbestos exposure and duration of employment

| Shipbuilding as "usual" industry | Reported asbestos exposure | No. of cases | No. of controls | Age-adjusted RR ^a | 95% confidence limits |
|----------------------------------|----------------------------|--------------|-----------------|------------------------------|-----------------------|
| Yes | Yes | 14 | 9 | 18.1 | 8.1-48.4 |
| | No | 15 | 14 | 10.3 | 5.9-31.5 |
| No ^b | Yes | 8 | 5 | 16.4 | 5.7-62.8 |
| | No | 2 | 23 | 1.1 | 0.2-6.1 |

^a All risks relative to persons never employed in shipbuilding and with no reported exposure to asbestos.

^b Employed in shipyards at some time, but this was not the usual occupation of the individual.

Table 4
Job titles of shipyard workers with mesothelioma

| | No. of shipyard workers | |
|--------------------------|----------------------------|--------------------------------|
| | Asbestos exposure reported | Asbestos exposure not reported |
| Pipcoverer | 6 | 2 |
| Pipefitter | 4 | 1 |
| Electrician | 3 | 4 |
| Machinist | 2 | 3 |
| Shipfitter | 2 | 0 |
| Welder | 2 | 1 |
| Boilermaker or inspector | 2 | 0 |
| Sheetmetal worker | 1 | 1 |
| Other ^a | 1 | 7 |
| Unknown | 1 | 0 |
| Total | 24 | 19 |

^a Includes 2 carpenters and a firefighter, guard, laborer, mechanic, rigger, and painter.

Table 5
RR for mesothelioma according to cigarette smoking category

| Cigarette smoking category | No. of cases | No. of controls | Age-adjusted RR ^a |
|------------------------------|--------------|----------------------|------------------------------|
| Never smoked | 15 | 42 (22) ^b | 1.0 (1.0) ^c |
| Other ^d | 41 | 192 (78) | 0.6 (0.8) |
| Current smokers ^e | | | |
| <0.5 pack/day | 6 | 11 (6) | 1.5 (1.5) |
| 0.5-1.5 packs/day | 22 | 91 (37) | 0.7 (0.9) |
| 2+ packs/day | 2 | 37 (15) | 0.1 (0.2) |
| Former smokers ^f | 10 | 46 (15) | 0.6 (1.0) |

^a All risks relative to those who never smoked cigarettes.

^b Numbers in parentheses, number of controls with causes of death not known to be related to cigarette smoking.

^c Numbers in parentheses, RR's computed using only controls with causes of death not known to be related to cigarette smoking.

^d Includes 1 case and 8 (5) controls known to have smoked but in unknown amounts. One control of unknown status is excluded.

^e These are individuals who smoked up to 10 years prior to death.

^f These are individuals who quit smoking at least 10 years prior to death.

DISCUSSION

Through the collaboration of area hospitals, it was possible to obtain first-hand information on the occurrence of all cases of mesothelioma reported among residents of Tidewater, Va. After procuring the original paraffin blocks of tissue specimens, an independent review of histological sections indicated that the diagnoses made by Tidewater pathologists were likely to

be correct in most cases, although the limited material available often precluded definitive confirmation. Thus, the nearly 4-fold elevated incidence of mesothelioma among white males in Tidewater seems unlikely to result from diagnostic or reporting bias. An excess of similar magnitude was reported recently in Kitsap county, near Seattle, Wash., where shipyards are also concentrated (12, 13). The coastal excesses of mesothelioma in the United States are consistent with the shipyard-related mesotheliomas reported in the port cities of several European countries (7-9, 22, 28). In our survey, three-fourths of the cases interviewed had worked in the ship construction and repair industry. The large majority were career employees who began work during or prior to World War II. The risks of mesothelioma were increased 18-fold among career shipyard workers reported to have handled asbestos and were nearly as high (16-fold) among temporary workers exposed to asbestos during the 1940's or earlier.

Although a significant excess of mesothelioma (10-fold) was also found among career shipyard workers who were not reported to handle asbestos, specific duties may not have been well known to the next of kin interviewed. Inadvertent exposures seem likely in the variety of shipyard jobs associated with mesothelioma in this study. An unusually high percentage were pipecoverers or pipefitters, but a number of other trades with presumably lighter asbestos exposures were reported. In radiological surveys, asbestotic lung changes have been found in a high percentage of current workers in east and west coast shipyards regardless of job within the shipyards (26), suggesting that airborne fibers are not confined to the immediate areas of use. Although the reported incidence of mesothelioma was not high among the female population of the Tidewater area, spread of asbestos beyond the workplace was suggested by the occurrence of mesothelioma in the wives of 4 shipyard workers.

Increased risks of lung cancer, on the order of 1.7-fold, have also been observed among men in coastal Virginia first employed before 1950 in area shipyards (3). Whereas most mesothelioma patients were career employees, most lung cancer patients who worked in the shipbuilding industry were short-term employees. Furthermore, few of the lung cancer cases were pipecoverers or pipefitters, the most commonly men-

tioned shipyard trade associated with mesothelioma. These findings suggest that more intense exposures may have been necessary, on the average, to induce mesothelioma than to induce lung cancer. Since the latent period (defined as the time from initial exposure to diagnosis of cancer) for asbestos-induced mesothelioma is usually reported to exceed 35 years (27), a sizable proportion of tumors related to asbestos exposures among wartime shipyard employees may not yet have occurred. Indeed, there is some suggestion among factory workers exposed to amosite asbestos (a major fiber type used in ship insulation) that latent periods may be longer than the duration of exposure (24).

In addition to the 43 cases of mesothelioma who were shipyard workers, 11 others had occupations with opportunity for asbestos exposure. Hence, asbestos seems to be the likely cause of nearly all of the 56 cases. Other surveys of mesothelioma have documented potential asbestos exposures in the majority of cases (21), but few studies (5) have reported exposure rates as high as in our study.

Cigarette smoking was not associated with an increased risk of mesothelioma, in contrast to its multiplying effect in asbestos-related lung cancer (10, 23). In fact, the data raised the possibility of an inverse association with amount smoked. There was a slightly smaller percentage of smokers among the cases when compared to those controls whose causes of death were unrelated to cigarette smoking, due mainly to a notable deficit of heavy smokers. Only 4% of the cases had smoked 2 packs per day or more versus 19% of these controls and 16% of a national sample of males (29). Although information on the smoking habits of mesothelioma patients is limited, in the largest series of cases the number of mesotheliomas observed among nonsmokers was equal to that expected (11), but calculations by amount smoked among smokers were not carried out. Our finding of a lowered risk of mesothelioma among heavy smokers needs future study but may be related in part to a competing risk of death, particularly from lung cancer and fibrosis, resulting from the greatly enhanced effects of asbestos among heavy smokers.

Although hospital resources were the primary means of identifying mesothelioma, the study was essentially population based. Nearly all the cases diagnosed among Tidewater residents were identified, so referral biases seem unlikely. Since mesothelioma is often rapidly fatal, controls were randomly chosen from deaths among all Tidewater residents of similar ages, and information for both cases and controls was obtained from the next of kin of recently deceased patients. The use of proxy respondents limited the amount and detail of occupational and other data (but probably not differentially between cases and controls). However, several comparisons of direct versus next of kin interviews have revealed concordance to be generally good for broadly defined variables, including smoking category and usual occupation (2, 15). The case/control ratios may have been affected by the lower response rate among controls and by the greater awareness of case families to asbestos exposures because of publicity surrounding this issue, but these differences seem insufficient to materially alter the substantial occupational risks.

Despite the inherent limitations of the methods used, this study implicates shipyard exposures to asbestos as responsible for the increased incidence of mesothelioma in coastal Virginia, as well as the parallel clustering of lung cancer. The

risk is large enough for mesothelioma to be considered a major cancer among men employed in area shipyards prior to 1950. Assuming that the Tidewater rate of 10 cases/year/100,000 white males ages 50 to 70 years (Table 1) is composed of a 15-fold increased risk among 12% (the percentage of the 236 controls) of this population who worked in shipbuilding prior to 1950 and either handled asbestos or were career employees, and assuming that the risk was usual among the remaining 88%, then the annual incidence of mesothelioma among former shipyard employees would be 56/100,000. This rate exceeds that for all cancers except those of the lung, prostate, colon, and bladder (6). Furthermore, since survival is poorer for mesothelioma than for the other neoplasms, mesothelioma may claim as many or more deaths among shipyard workers than does any cancer except lung cancer. Since stricter controls have been instituted to reduce asbestos exposure in shipyards (16), mesothelioma incidence should eventually decline in coastal areas of the country such as Tidewater. However, the long latent period of asbestos-induced mesothelioma is a matter of concern, and it seems likely that the full impact of postwar exposures has not yet been seen.

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