FILE NAME: Brakes (BRK)

DATE: 2004

DOC#: BRK167

DOCUMENT DESCRIPTION: Journal Article - Mesothelioma Among Brake Mechanics: An Expanded Analysis of a Case-Control Study

Risk Analysis, Vol. 24, No. 3, 2004

Mesothelioma Among Brake Mechanics: An Expanded Analysis of a Case-Control Study

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The U.S. Environmental Protection Agency has begun discussions to consider its assessment of asbestos toxicity related to mineral form and fiber size. Brake workers are typically exposed to short chrysotile fibers. To explore the mesothelioma risk among brake workers, considering other occupational exposures to asbestos, data from a study that was published previously were obtained and the analysis was extended. The National Cancer Institute provided data from a case-control study of mesothelioma. Because many participants with a history of brake work also had employment in other asbestos-related occupations, mesothelioma cases and controls were compared for a history of brake work, controlling for employment in eight occupations with potential asbestos exposure. A stratified analysis was also performed excluding those with any of the eight occupations. Possible interactions between brake work and other occupational exposures related to risk of mesothelioma were also examined. The odds ratio (OR) for employment in brake installation or repair was 0.71 (95% CI: 0.30–1.60) when controlled for insulation or shipbuilding. When a history of employment in any of the eight occupations with potential asbestos exposure was controlled, the OR was 0.82 (95% CI: 0.36–1.80). ORs did not increase with increasing duration of brake work. Exclusion of those with any of the eight exposures resulted in an OR of 0.62 (95% CI: 0.01–4.71) for occupational brake work. There was no evidence of an interaction between brake work and other occupational exposures. These latter analyses were based on small numbers of exposed cases. The results are consistent with the existing literature indicating that brake work does not increase the risk of mesothelioma and adds to the evidence that fiber type and size are important determinants of mesothelioma risk.

KEY WORDS: Asbestos, auto mechanics, friction brake products, mesothelioma

1. INTRODUCTION

In February 2003, the U.S. Environmental Protection Agency (EPA) announced plans to evaluate an asbestos cancer risk assessment methodology that would distinguish carcinogenic potency by fiber type and size.(1) As noted in the announcement, the existing assessment has not changed since 1986 despite substantial improvements in asbestos measurement techniques and better understanding of how asbestos exposure contributes to disease.

A large number of epidemiologic studies have been examined to address the comparative potencies of chrysotile and the amphibole asbestos fibers.(2) Animal studies have proved disappointing either because the routes of exposure used in these studies (i.e., peritoneal or intratracheal instillation) bypass clearance mechanisms or because of the low sensitivity of

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0272-4332/04/0100-0547$22.00/1

the inhalation test model.[3] Consideration of fiber length and diameter, however, has typically relied on experimental evidence (toxicology and lung burden studies).[4] Given the Agency's renewed interest in mineralogy and fiber size, studies of those exposed primarily to short chrysotile fibers are especially relevant.

Automotive brakes have historically been made from friction materials containing only the chrysotile form of asbestos. Motor vehicle mechanics who installed and repaired brakes were exposed primarily to short chrysotile fibers with low time-weighted average exposures and intermittent, higher, short-term exposures during certain parts of the process.[5] Studies by the National Institute of Occupational Safety and Health in the late 1970s and early 1980s found time-weighted average exposures for mechanics to fibers greater than 5 μm in length and with at least a 3:1 aspect ratio during brake jobs, ranging from 0.01 to 0.28 f/cc.[6,7] Fiber size distribution analyses of these samples indicated a geometric mean length of 1.70 μm (range 0.24–10.0) and diameter of 0.15 μm for airborne chrysotile asbestos fibers.[7]

A number of studies have examined the association between motor vehicle repair (in general) or brake work (in particular) and mesothelioma.[8–14] None of these have demonstrated a positive association. A recent meta-analysis found that the relative risk of mesothelioma among auto mechanics was 0.90 (95% confidence interval (CI): 0.66–1.23).[15]

Addressing mesothelioma risk among brake workers is complicated by their frequent involvement in other occupations with potential asbestos exposure. This was noted in a case-control study by Spirtas *et al.*[16] Thirty-three of the 208 cases (15.9%) and 72 of the 533 controls (13.5%) had worked on brakes. A risk estimate was not calculated because many brake workers had also worked in shipbuilding or insulation.

The purpose of the present analysis was to explore the relationship between brake installation/repair and mesothelioma in the data set originally described by Spirtas *et al.*[16] after adjustment for employment in occupations with known increased risk of mesothelioma, and to determine whether these results support the proposed new methodology for asbestos risk assessment.

2. METHODS

2.1. Previous Study

The study of Spirtas *et al.*[16] included cases diagnosed from 1975 to 1980 and registered by the Los Angeles County Cancer Surveillance Program, the New York State Cancer Registry (excluding New York City), and 39 large Veterans Administration (VA) hospitals. Of 720 eligible cases, next of kin of 536 (74%) were successfully interviewed. Pathological material was available to confirm the diagnosis for 426 (79%). Of these, 208 (49%) were accepted as definite or probable mesotheliomas.

Controls for cases in New York State and Los Angeles County were selected from death certificates. Controls for cases from VA hospitals were selected from those who had died and received medical and financial benefits from the VA. Controls were initially matched by date of birth, race, sex, year of death, and county of residence (for those in New York State and Los Angeles County) or hospital (for those from the Veterans Administration) to the larger group of cases. Of the 687 eligible controls, interviews were completed with next of kin of 533 (79%). Because the number of controls who responded was much greater than the number of cases accepted as having definite or probable mesothelioma, all controls with completed interviews were included and the analysis was unmatched. The same analytical approach was used for the present analysis.

The interviews requested information about asbestos exposure in general, and specifically about involvement in nine activities with potential asbestos exposure. These included brake lining installation or repair, furnace or boiler installation or repair, building demolition, plumbing or heating repair, insulation, shipbuilding/ship demolition/shipyard work, elevator installation or repair, production of textiles, and production of paper products. For the first five activities, data were available on whether the activity was job related, nonjob related, or both job and nonjob related.

All interviews were conducted with next of kin and the interviewers assessed, subjectively, the quality of the occupational histories. Eighty-three percent of the interviews for cases and 90% for controls were rated as highly or generally reliable. The authors recognized the possible failure of next of kin to recall all opportunities for asbestos exposure, especially in the distant past.

Of the brake workers, 32% did this as part of their job, 57% did it "on their own time," and 10% did both. For the present analysis, those who did brake work as part of their job and those who did both were considered occupationally exposed. Cases and controls were similarly distributed for occupational and nonoccupational brake work.

2.2. Present Analysis

The electronic data and documentation were obtained from the National Cancer Institute. To ensure that the data had been correctly converted, the first three tables in the original paper were recreated.[16] For the most part, these tables could be reconstructed exactly. Where changes were noted, these resulted from the apparent clarification of missing data (i.e., there were fewer missing values for age at death in the present data set compared to the previous report).

The questionnaires of five cases and 12 controls had missing values for brake work. The occupational histories of four of the five cases were coded as questionable quality and one as unreliable. For the controls, six were questionable, three were generally reliable, and three were highly reliable. Those with missing responses were excluded from the analyses. This reduced the number of subjects classified as nonexposed relative to the original report, in which those with missing information were classified as nonexposed.

There were no female brake workers, only two nonwhite females in the study group (both controls), and 16 nonwhite males (three cases and 13 controls).

After examining the distributions of race and sex, and considering the ratings of the quality of the occupational histories and the types of brake work (occupational and nonoccupational), it was decided *a priori* that the most relevant analyses would come from:

1. white males,
2. with highly or generally reliable work histories,
3. with a nonmissing response for brake work, and
4. whose brake work was occupational.

Of the 28 cases and 63 controls meeting the first three criteria, 12 cases and 28 controls did occupational brake work (Table I). The remainder did it on their own time.

The data were analyzed using unconditional logistic regression, controlling for age. For the initial analysis of all relevant variables and for the analyses of shipbuilding and insulation, age was entered as a continuous variable and large sample methods were used. For the analyses of subsets of brake work, age was categorized in five-year age groups (<40, 40–44, 45–49, . . . , 85+) and exact methods were used. Categorization of age facilitated convergence of the model. Because smoking is not related to mesothelioma, this was not controlled in the analysis (unlike the original report). Decisions regarding inclusions, exclusions, and analytical strategies were made before risk estimates were calculated.

To examine the effect of exposure to brake work, three approaches for controlling the effects of other asbestos exposures were used. The first analysis included all relevant terms in a single model. In this model, age was entered as a continuous variable and 0/1 variables were entered for absence or presence, respectively, of occupational brake work, nonoccupational brake work, shipbuilding, insulation, and any of the remaining six activities. In this analysis, those with nonoccupational brake work and those with no brake work were coded as 0 (i.e., not exposed) for occupational brake work. Those with occupational brake work and those with no brake work were coded as 0 for nonoccupational brake work.

To more clearly distinguish occupational and nonoccupational brake work, a second set of analyses compared brake workers with nonbrake workers in separate analyses. For the analyses of any brake work, those with no history of brake work (occupational or nonoccupational) were considered nonexposed. For the analysis of nonoccupational brake work, those with no history of brake work were considered nonexposed and those with occupational brake work were excluded. For the analyses of occupational brake work, those with nonoccupational

Table I. Numbers of Cases and Controls by Exposure Subset

Subset	Cases	Controls
All	203	521
Those meeting selection criteria[a]	147	358
Brake work		
None[b]	119	295
Nonoccupational	16	35
Occupational	12	28
<10 years[c]	5	10
≥10 years	6	16
No shipbuilding or insulation	2	15
None of eight listed activities[d]	1	9

[a]White males with highly or generally reliable work histories and nonmissing response for brake work.
[b]Of these, 33 cases and 171 controls were not exposed to any of the eight listed activities.
[c]Length of occupational brake work was missing for one case and two controls.
[d]The eight activities included furnace or boiler installation or repair, building demolition, plumbing or heating repair, insulation, shipbuilding/ship demolition/shipyard work, elevator installation or repair, production of textiles, and production of paper products.

Table II. Regression Coefficients (β), Standard Errors (SE), Odds Ratios (OR), and 95% Confidence Intervals for Brake Work, Controlling for Age and Activities Potentially Entailing Asbestos Exposure

Variable	β	SE	Odds Ratio	95% Confidence Interval
Age	0.011	0.009	1.01	0.99–1.03
Occupational brake work	−0.307	0.378	0.74	0.35–1.54
Nonoccupational brake work	−0.184	0.332	0.83	0.43–1.59
Shipbuilding	1.798	0.244	6.04	3.74–9.75
Insulation	1.216	0.218	3.38	2.20–5.17
Other activities[a]	0.028	0.199	1.03	0.70–1.52

[a]The other activities included furnace or boiler installation or repair, building demolition, plumbing or heating repair, elevator installation or repair, production of textiles, and production of paper products.

brake work were excluded and those with no history of brake work were considered nonexposed. This analysis was repeated, including a single variable for presence of shipbuilding or insulation (=1) or absence of both exposures (=0). These were the two potentially confounding occupational exposures noted by Spirtas *et al.*[16] Then the analysis was repeated, controlling for work in any of the eight activities considered in the original report. A single variable for presence of any of these exposures (=1) or absence of all of these exposures (=0) was entered. To evaluate the relationship with length of occupational exposure in these analyses, subjects were classified as having no occupational brake work, less than 10 years, or at least 10 years.

The last approach dealt with the potential effects of asbestos exposures through exclusion. Cases and controls were compared for a history of occupational brake work, excluding those with any of the eight activities.

To assess the potential joint effects of brake work and other exposures, interaction terms were entered into the multivariate models. In addition, odds ratios (ORs) were compared for workers in insulation and shipbuilding who either did or did not also have a history of brake work.

3. RESULTS

The results of the full model demonstrated positive associations between mesothelioma and both shipbuilding and insulation (Table II). There was no association between mesothelioma and either occupational or nonoccupational brake work, nor was there an association with the other six activities with potential asbestos exposure.

Similarly, the analyses that separated occupational and nonoccupational brake work found no associations (Table III). The analysis by duration of employment showed no suggestion of increasing risk of mesothelioma with increasing length of time employed in brake work. When the interactions between brake work and activities involving potential asbestos exposure were examined, there were no patterns suggesting that brake work enhanced the risk associated with other asbestos exposures (data not presented). When participants with any of the eight activities were deleted from the analysis, the OR for occupational

Table III. Odds Ratios (OR) and 95% Confidence Intervals (95% CI) for Association Between Brake Work and Mesothelioma Controlling for Age and Activities Potentially Entailing Asbestos Exposure

					Occupational					
	Any Brake Work		Nonoccupational		Any		<10 years		≥10 years	
Controlled for	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
No activities	1.03	0.59–1.75	0.99	0.48–1.96	1.04	0.46–2.22	1.32	0.39–3.97	0.86	0.26–2.41
Shipbuilding/insulation	0.74	0.42–1.30	0.74	0.34–1.53	0.71	0.30–1.60	0.99	0.27–3.22	0.53	0.15–1.60
All eight activities[a]	0.82	0.46–1.41	0.79	0.37–1.61	0.82	0.36–1.80	1.03	0.30–3.22	0.68	0.21–1.98

[a]The eight activities included furnace or boiler installation or repair, building demolition, plumbing or heating repair, insulation, shipbuilding/ship demolition/shipyard work, elevator installation or repair, production of textiles, and production of paper products.
Note: Odds ratios and 95% confidence intervals based on exact methods.

Table IV. Age-Adjusted Odds Ratios (OR) and 95% Confidence Intervals (CI) for Insulation Workers and Shipbuilders by History of Brake Work

Exposure Group	No History of Brake Work		History of Brake Work	
	OR	CI	OR	CI
Insulators	4.14	2.55–6.77	1.74	0.69–4.46
Shipbuilders	5.16	2.94–9.23	4.36	1.36–14.8

Note: Brake work included both occupational and nonoccupational brake work.

brake work was 0.62 (95% CI: 0.01–4.71) based on one exposed case and nine exposed controls.

The age-adjusted OR for insulation workers who had no history of brake work was 4.14 (95% CI: 2.55–6.77), and for insulators who were also brake workers, the OR was 1.74 (95% CI: 0.69–4.46) (Table IV). For shipbuilders with no employment as brake workers the OR was 5.16 (95% CI: 2.94–9.23) and for shipbuilders with employment as brake workers, the OR was 4.36 (95% CI: 1.36–14.8).

4. DISCUSSION

The present analysis focused on the question of the potential risk of mesothelioma associated with brake work, while considering other activities involving potential asbestos exposures. The results were consistent with the available literature that demonstrates no apparent risk. The present analysis used occupational histories evaluated as reliable by the interviewers. The results changed little and no conclusions differed when all respondents were included, regardless of the quality of the work history. Similarly, including nonwhites had no discernable effect.

The study was limited by the relatively small numbers of brake workers, especially in the analyses that excluded those with other potential asbestos exposures. The confidence intervals were reasonably narrow for the overall analyses, but those for the interaction terms were quite broad. In the stratified analysis, only one case and nine controls with occupational brake work did not hold one of the other jobs involving asbestos exposure. The original study[16] excluded from the control group those who died from cancer and respiratory disease because the researchers felt that they might be related to asbestos exposure. If these diseases were positively associated with asbestos exposure in this population, the risk estimates for occupations with asbestos exposure may have been overestimated.

The results indicated no excess risk of mesothelioma among brake workers when the analyses were controlled for exposures in occupations with known risk of mesothelioma. Further, there was no evidence of an exposure-response relationship between brake work and mesothelioma. This was evident in the analysis by duration of occupational brake work and the fact that the ORs for occupational brake work were indistinguishable from those for nonoccupational brake work. It is assumed that, on average, those with occupational brake work would have had higher exposures than those with nonoccupational brake work.

These findings are consistent with no increase in risk of mesothelioma associated with short chrysotile fibres (<5 μm in length). There is increasing evidence that such fibres may not be carcinogenic.[4,17] Explanations for the observed results may include the following: (1) time-weighted average exposures are low in this occupational group;[5,7] (2) most of the fibers are short;[6,7] (3) chrysotile asbestos is used almost exclusively;[17] (4) the fibers are embedded in resin; (5) much of the asbestos is transformed to forsterite (a nonfibrous substance) during the braking process; and (6) only a small percent of "brake dust" is asbestos.[5] The findings for brake mechanics reinforce the caution that direct inferences from one occupational setting to another without consideration of the key determinants of risk are to be avoided.[18]

ACKNOWLEDGMENTS

The authors thank Dr. Aaron Blair from the National Cancer Institute for providing the data. They also thank Dr. Robert Spirtas for helpful comments. The project was funded by Daimler Chrysler, Ford Motor Company, and General Motors Corporation. Drs. Hessel, Teta, and Goodman have provided scientific consulting services to these companies in the area of friction brakes.

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