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Potential source of asbestos in non-asbestos textile manufacturing company

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Abstract

Recently, a worker with lung carcinoma and a metastatic brain tumor was diagnosed as having a work-related disease. He had been employed in a non-asbestos textile company for 25 years. Consequently, to identify and explore possible causative agents for lung cancer in a non-asbestos textile manufacturing company and establish a causal relationship between exposure and lung cancer, an epidemiological investigative study was conducted and the work processes the worker was engaged in were examined. Air samples were taken from the workplace and during the drilling processes, and a suspected causative material was analyzed. The study revealed that the subject had been employed in the non-asbestos textile manufacturing company for 25 years from 1973 and his responsibilities included repairing spinning machines. In particular, the subject was involved in drilling B-bushings that were used to protect against gear abrasion in the spinning machines. An analysis of the B-bushings using a transmission electron microscope equipped with an energy dispersive X-ray analyzer indicated that they contained crocidolite asbestos fibers. Air samples obtained when drilling the B-bushings clearly indicated that the subject had most likely been exposed to crocidolite fibers when installing the B-bushings in the spinning machines. The frequency and duration of the work suggested that there would be a sufficient degree of exposure to crocidolite fibers to cause lung cancer. Except for smoking and asbestos exposure, no other chemical exposure was suspected for developing lung cancer in the workplace. Smoking appeared to be more of a potentiating risk factor in conjunction with the asbestos exposure. Accordingly, this case may provide significant evidence in identifying the cause of the mesothelioma or lung carcinoma found among workers in non-asbestos textile manufacturing companies elsewhere.

Keywords: Asbestos; Non-asbestos textile manufacturing company; Crocidolite; Lung cancer; B-bushing; Occupational disease; Drilling

1. Introduction

A causal relationship between asbestos exposure and subsequent mesothelioma or lung carcinoma has already been clearly established and many occupations have since been identified as being at risk (Wagner et al., 1960; Selikoff and Lee, 1978; IARC, 1982). As such, the higher-than-normal ratio of lung cancer in non-asbestos textile industries has been attributed to several causative agents (Paci et al., 1987a,b; Quinn et al., 1987). Those who have "ever worked" in the textile industry show an adjusted odds ratio of 1.52 compared with other industrial workers. Suggestions as to the possible source of exposure to asbestos in a non-asbestos textile industry have included asbestos-contaminated bags, which once contained asbestos (Quinn et al., 1987) or imported rags mixed with asbestos-contaminated clothing (Paci et al., 1987a,b). However, no definite causative source of asbestos for the diseases occurring in non-asbestos textile manufacturing companies has yet been identified.

In 1999, a male worker who developed lung carcinoma accompanied by a metastatic brain tumor was diagnosed as

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having a work-related disease after the case was reviewed by the Occupational Disease Review Committee (ODRC) in the Occupational Safety Health Research Institute (OSHRI), Korea Occupational Safety Health Agency (KOSHA), and the Ministry of Labor (Choi, 1999). The criteria for the diagnosis were: (1) the subject was healthy before starting this job, (2) no other causes of lung cancer were identified except crocidolite exposure and smoking, (3) smoking may have pontentiated the asbestos toxicity, and (4) lung cancer can be a work-related disease. An epidemiological study of the relevant workplace indicated that the worker could have been exposed to asbestos while repairing spinning machines (Choi et al., 1999). Therefore, the objectives of the current paper were to investigate possible causative agents of lung cancer in a non-asbestos textile manufacturing company and establish a causal relationship between exposure and lung cancer.

2. Method

2.1. Work environment investigation and patient history

An epidemiological investigation team surveyed the workplace and the work processes in which the subject had been involved, such as gear pump repairing and testing, B-bushing installation and gear pump assembly and installation, were also analyzed and documented. The workplace was also investigated to establish the potential for exposure to any hazardous materials. The B-bushing that was suspected of containing asbestos was provided by the worker's supervisor. Finally, the subject was interviewed to establish his work history and medical history. Additional information on the subject was obtained from his applications for workers compensation and Kosin University Hospital patient records. Personal breathing zone air samples were collected during working hours. The samples were taken by drawing air through mixed cellulose filters in sampling cassettes (25-mm diameter, 0.8-μm nominal pore size, 2-in. cowl) obtained from Environmetrics (cat no. 20-31-0-1401, Charleston, USA) using SKC battery-operated sampling pumps at a flow rate of 2.0 l per minute.

2.2. TEM-EDX analysis

The B-bushing sample was broken into small pieces and then powdered using a pestle. The powdered sample was suspended in 50 ml distilled water and filtered through a 0.2-μm nucleopore filter (Nucleopore, Pleasanton, CA). The filter was coated with carbon and mounted onto carbon-coated nickel grids (Veco, Eerbeek, Holland) using chloroform vapor. The asbestos fibers were morphologically identified by a transmission electron microscope (TEM, Hitachi 7100, Tokyo, Japan), while the asbestos types were determined by comparing the elemental composition of the asbestos fibers using an energy dispersive X-ray analyzer (EDX, 7000Q, KEVEX, Foster City, CA).

3. Results

3.1. Subject history

A male worker, 50 years old in 1998, was employed in a textile manufacturing company from November 12, 1973 and originally assigned to the cleaning division of the repair department. Then, from 1983 to July 1998, he was assigned to repairing and testing the gear pumps in the spinning machines and changing the B-bushings in the gear pumps. Before taking this job, he was healthy and had no specific occupational history. The subject previously received compensation from the Workers' Accident Compensation Insurance (WACI) two times; first for the amputation of his right third finger due to accidental sandwiching between gears on July 7, 1984, and second for an injury to his left eye due to a fragment during drilling on October 19, 1989. After being hospitalized in July 1998, the subject made two further applications for compensation from the WACI; however, his claims for disease caused by exposure to nitric acid and dimethyl formamide (DMF) were denied due to the lack of specific causal evidence linking lung cancer to nitric acid or DMF exposure. The subject smoked one pack of cigarettes per 3 days for 27 years and drank one bottle of Soju (360 ml, 25% ethyl alcohol) per week. After 1993, the subject had

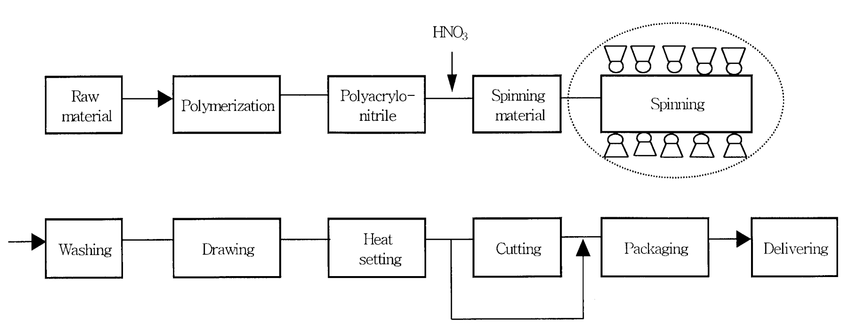

Fig. 1. Work processes of the textile company.

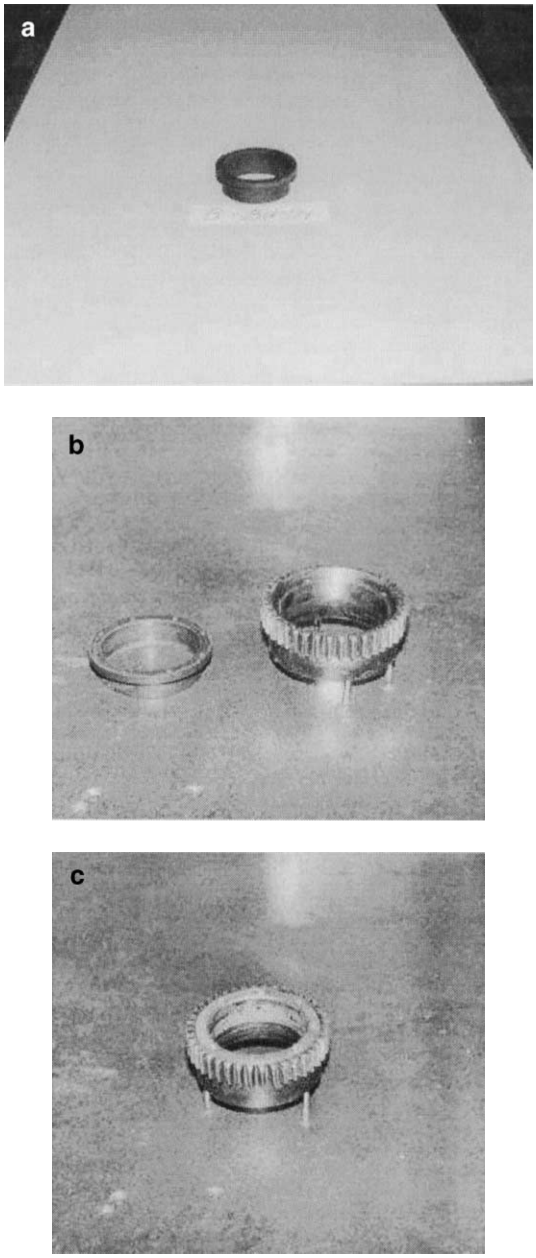

Fig. 2. B-bushing. (A) B-bushing. (B) B-bushing disassembled from gear pump. (C) Assembled gear pump including B-bushing.

sole responsibility for repairing and testing the gear pumps. His health was recorded as normal in annual check-ups in 1993 and early 1998, including chest X-rays. In July 1998, the subject was forced to take a leave of absence from his job as he was suffering from severe headaches, felt weakness in his left leg, and was experiencing visual disturbance. The results of an MRI scan on July 13, 1998 at T hospital indicated a possible brain tumor. The subject then underwent a whole-body gallium scan at Kosin University Hospital at the end of July 1998, which recorded a mild abnormal gallium uptake in the right lower paratracheal area and multiple lymph node uptake in the right lower cervical and upper paratracheal areas. Although a lung biopsy was not conducted, the pleural cytology showed characteristics of adenocarcinoma. Therefore, at Kosin University Hospital, the subject was diagnosed with bronchogenic carcinoma in the right upper lobe with a metastatic brain tumor. Surgery was performed to remove the brain tumor. The primary cancer was identified in the lungs because the brain surgical specimen and pleural fluid cytology revealed adenocarcinoma and no other pathological findings were observed in other tissues, including the stomach, colon, liver including the bile duct and pancreas. An endoscopic examination also showed no other specific findings. A pulmonary function test showed a moderate airway obstruction. On November 23, 1998, the subject made another application to WACI, claiming that his disease had been caused by asbestos exposure. OSHRI performed an investigative study at the workplace on December 11, 1998. On January 27, 1999 the lung carcinoma accompanied by the metastatic brain tumor was diagnosed as being a work-related disease after review by the ODRC. Despite receiving anticancer therapy and radiotherapy, the subject died in June 1999.

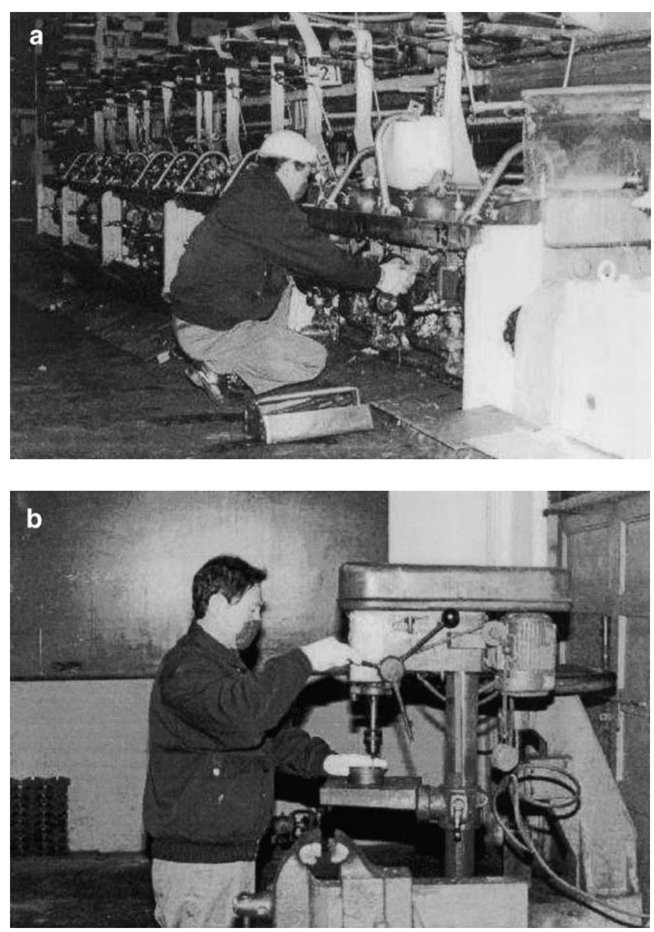

Fig. 3. Gear pump disassembling and installation. (A) Disassembling gear pump. (B) Drilling B-bushing.

3.2. Investigation of work processes to determine hazardous material exposure

The workplace investigation was conducted on December 11, 1998 after the subject made an application to WACI on November 23, 1998.

3.2.1. Gear pump repairing and testing

The work processes of the textile manufacturing company are shown in Fig. 1. The company produces artificial fibers by spinning polyacrylonitrile and drawing the spun fibers. Nitric acid and DMF are both used in this process. The subject was engaged in gear pump repair and testing during which the gear pumps were removed from the spinning machines, transferred to the repair room, and then disassembled and soaked in water for 1 day. After being thoroughly cleaned, the gear pumps were reassembled and tested for proper operation. The subject changed a gear pump approximately every 1 or 2 days.

3.2.2. Gear pump disassembling and installing

A B-bushing, shown in Fig. 2, is a protective attachment on the wheel that shields the outgear from friction during operation. The subject removed the gear pumps from the spinning machines (Fig. 3A) and disassembled them. The B-bushings and gear pumps were then drilled to make holes (Fig. 3B) for bolts and assembled, as seen in Fig. 2C. Finally, the assembled gear pumps were installed into the spinning machines.

This B-bushing installation work continued until 1987, when the original B-bushings were replaced with the current Teflon–carbon B-bushings. The B-bushings used before 1987 were a blue gray color and known to be comprised of asbestos-containing material; they were also composed of a harder material than the one currently used. The current B-bushings are supplied with predrilled holes for the fastening bolts, whereas the old ones required holes to be drilled. When workers drilled the holes, it took 40–50 min to drill 50 holes during the work period. The frequency of the drilling work was once every 2 months and the same four workers were involved on each occasion. The workers involved in the drilling operation did not experience any problems, except for an odor and the dust generated from the drilling that accumulated near the drill board.

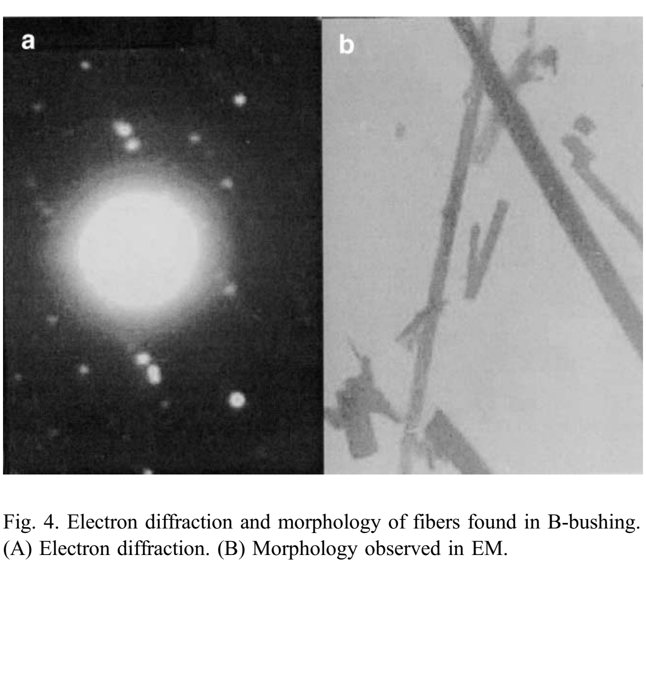

Fig. 4. Electron diffraction and morphology of fibers found in B-bushing. (A) Electron diffraction. (B) Morphology observed in EM.

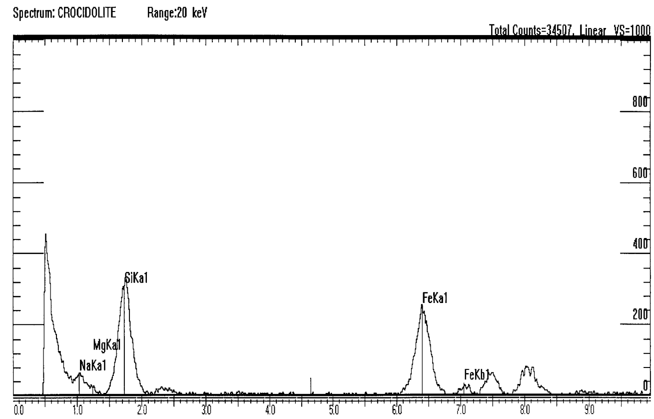

Fig. 5. EDX spectrum of fibers found in B-bushing.

3.3. Analysis of B-bushing by TEM-EDX

A B-bushing, kept for more than 10 years by the workers, was handed over to the epidemiological investigation team in the presence of the factory supervisor. The supervisor and workers both recognized the B-bushing as the type used before 1987. When the sample was analyzed by a TEM-EDX, it was found to contain fibrous materials, as shown in Fig. 4B. These were identified as crocidolite fibers when analyzed by electron diffraction (Fig. 4A) and EDX (Fig. 5).

3.4. Air sampling

Air samples taken near the spinning and weaving machines for 20–40 min as personal breathing zone samples during the work period on December 11, 1998 did not show any asbestos fibers. To identify asbestos generation during the drilling process, drilling was performed on the sample B-bushing for 5 min in several locations and air samplings performed; 0.75 crocidolite fiber/cc and 0.3 crocidolite fiber/cc were detected near the drill and in the breathing zone, respectively.

4. Discussion

Although the presence of asbestos fibers was neither confirmed in a lung biopsy sample from the subject nor in air samples obtained from the workplace, the ODRC determined the subject as having as a work-related disease because exposure to crocidolite, which is now banned for all purposes in Korea, could not be excluded as the cause of the lung cancer. The frequency and duration of the work, 40–50 min per work period for at least 4 years (1983–1987) installing B-bushings containing asbestos and 14 years of possible exposure (1973–1987) from workplace ambient air clearly suggest a sufficient degree of exposure to crocidolite fibers to cause lung cancer. The subject was healthy when he started the work and exceeded the 20-year latency period of asbestos exposure for lung cancer. Except for smoking and asbestos exposure, no other chemical exposure, such as nitric acid or DMF, was considered to have a causal link with the development of lung cancer in the workplace. Although the subject smoked cigarettes for 27 years, this was considered as more of a potentiating risk factor combined with his asbestos exposure. The patient died after the approval for compensation was given. Based on advice from the physician in charge, no lung biopsy samples were taken due to health considerations. Therefore, even though the presence of crocidolite fibers in the subject's lungs was not definitely established due to the refusal of an autopsy by the subject's family insisting on Korean traditional custom where a dead body is treated as if alive, this case could be the first clue in identifying the cause of lung cancer found among workers in non-asbestos textile manufacturing companies elsewhere. The current study suggests that exposure to asbestos in a non-asbestos textile manufacturing company may be possible based on inhalation of asbestos fibers while repairing parts containing asbestos. Alternatively, a worker could also be exposed to ambient asbestos fibers generated from machine parts in a non-asbestos textile manufacturing industry. Further investigation revealed that seven more workers were involved in the drilling operation. These workers are now under the Health Management Program for Workers in Changed Occupations, in which workers previously involved in handling carcinogens receive periodic health checks even if they change their job. Despite several attempts to identify the exact cause of asbestos-exposure-related diseases in non-asbestos textile workers, no clear evidence has yet been documented (Paci et al., 1987a,b; Quinn et al., 1987). However, it is possible that non-asbestos textile manufacturing industry workers are still being exposed to asbestos fibers in the workplace as B-bushings containing asbestos or other brake-operating parts containing asbestos may yet be present or have been previously used in some workplaces. In addition, there is also a risk that such B-bushings or other brake parts can generate the presence of asbestos fibers in the ambient air in the workplace. Accordingly, since asbestos-related cancer is known to develop 20–30 years after initial exposure, this poses cancer risks for the future.

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