Journal of Radiology Nursing xxx (2017) 1–6

Contents lists available at ScienceDirect

Journal of Radiology Nursing

journal homepage: www.radiologynursing.org

Asbestos-Related Disease

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Keywords:
Asbestos
Mesothelioma
Asbestosis
Lung cancer

A B S T R A C T

Asbestos exposure results in a spectrum of respiratory diseases. Both mesothelioma and lung cancer are directly associated with exposure to asbestos usually after a long latency period, whereas other noncancerous diseases such as asbestosis result in crippling debility. Nonetheless, asbestos has proven to be a useful and valued mineral for thousands of years. In this review, the history, diagnosis, and societal costs of asbestos use are explored.

Introduction

Any master storyteller knows that all good magic carries a price. Having straw spun into gold will cost you your firstborn. Magical red shoes will make you dance until you drop. Being a king with a golden touch has a serious downside. In the real world, human history has suffered its own tragic twists of alchemy, one of the most visible examples being asbestos. It indeed appears to be a magical substance: it does not burn; it is lightweight, but strong; and it is an ideal material for insulation. However, it comes with tragic costs. Although the mining of asbestos has ceased in the United States, and its use significantly curtailed, the invoice to society is still being tallied. Asbestos exacts its price decades after exposure. Automobile mechanics, ship builders, and ship breakers are the obvious candidates who come to mind, but the thriving nature of the asbestos abatement industry is testament to the legacy of humanity's long enchantment with this magical substance. The focus of this review is the medical and societal consequences of asbestos exposure.

The paradox of asbestos

Early Use of Asbestos

Asbestos in the real world is as ubiquitous as fairy dust in a bedtime story. As a result, nearly every human civilization has found ways to use the substance. Paintings, pots, lamp wicks, and other ancient artifacts suggest that humans have used asbestos since at least 5000 BC (Buckley & Evershed, 2001; Selikoff, 1990). The ancient Egyptians effectively preserved the bodies of their pharaohs in asbestos cloth. Although Roman scholar Pliny the Elder often gets credit for the earliest documentation of the detrimental effects of mining and use of asbestos, the Greek historian Strabo probably preceded him describing a respiratory sickness in slaves who mined the substance (Buckley & Evershed, 2001).

In the 8th century, the emperor Charlemagne found that when woven into tablecloths and napkins, it was easy to launder by merely tossing the cloth into fire (Bianchi & Bianchi, 2015). Marco Polo similarly described clothing that could be laundered in fire (Bianchi & Bianchi, 2015). Beyond lamp wicks, pots, and an obsession with avoiding laundry, our knowledge of asbestos use in the ancient world is little more than apocryphal. In the 19th century, however, the commercial importance of asbestos began to pick up speed, and with it, the identification of maladies peculiar to the asbestos industries.

Emergence as an Occupational Disease

Etiology aside, the recognition of asbestos-related diseases as a distinct entity developed slowly (Smith, 2005). The earliest mention in the medical literature of what was likely mesothelioma was in 1767 when the French pathologist Lieutaud documented two cases of pleural tumors in a study of 3,000 autopsies (Lieutaud, 1767). Subsequent discussion in the medical community centered on whether such pleural malignancies were primary or secondary in nature. In 1819, Laennec suggested that the malignancy could be primary, arising directly from the pleura (Laennec, 1819). It was not until the early 20th century that an understanding of the true nature of mesothelioma began to emerge. In 1924, Robertson at the

Conflict of interest: The authors have no conflicts of interest to report.

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https://doi.org/10.1016/j.jradnu.2017.12.003
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Mayo Clinic published a landmark review of the literature to that date, from which he concluded that there was no justification for diagnosing mesothelioma as a secondary cancer (Robertson, 1924).

Although a temporal relationship between handling of asbestos and development of illness had been observed for centuries, the discovery of a causal relationship is a more recent development. In 1924, the same year as Robertson's review, Cooke published a report in the *British Medical Journal* of death from asbestos fibrosis of the lungs and tuberculosis in the unfortunate Nellie Kershaw, a young asbestos spinner (Cooke, 1924). Cooke directly linked her fibrosis to inhalation of asbestos dust. In 1928, after a case of pulmonary fibrosis in a Glasgow asbestos worker, British factory inspectorate Merewether was instructed to ascertain whether such disease in asbestos workers represented an occupational health risk or was merely coincidence (Bartrip, 1983). Ultimately, investigation by Merewether confirmed the existence of a fatal disease associated with occupational exposure to asbestos dust: asbestosis. Subsequently, in 1931, the British government enacted the Asbestos Industry Regulations, requiring simple dust suppression measures (Bartrip, 1983).

As the 20th century unfolded, and industrialization escalated, the occupational implications of asbestos exposure became apparent. It is Wedler, however, who is widely cited as publishing the first specific report of pleural malignancy associated with asbestosis. In 1943, Wedler reported findings in 29 autopsies of asbestos workers in Germany (Wedler, 1943). Although these findings were given credence at home, they were largely ignored outside Nazi Germany. It is notable that in the same year the German government recognized asbestos in combination with lung cancer as a compensable disease. Years after the war, the work by Wedler was cited by German pathologist Weiss when he reported on patients with cancer of the pleura, including a German insulation worker with asbestosis who had worked for 15 years as an insulator in the construction of warships (Weiss, 1953), spending as much as 90 min a day in a room filled with asbestos dust. Two years later, the annual report of the Chief Inspector of Factories of Great Britain revealed that 17.8% of worker deaths with asbestosis also had cancer of the lung or pleura (Bartrip, 1983). Later that year, Richard Doll studied these same findings, concluding that lung cancer was a specific industrial hazard of certain asbestos workers (Doll, 1955).

A watershed year for widespread recognition of a relationship between mesothelioma and exposure to asbestos, including occupational, was 1960. That year, Wagner published an article describing 33 cases of diffuse pleural mesothelioma in workers exposed to Cape Blue (crocidolite) asbestos in the mines of Cape Province in South Africa (Wagner, Sleggs, & Marchand, 1960). Although the article and its conclusions were criticized for methodology, Wagner et al. were not alone in their suspicions, as the evidence in the published literature piled higher.

In 1964, Selikoff et al. published a review of the records of the New York metropolitan area Asbestos Workers Union members from 1942 to 1962 (Selikoff, Churg, & Hammond, 1964). Of the 632 insulation workers followed, 45 died of cancer of the lung or pleura, and another 12 died of asbestosis, far above mortality rates expected for these diseases. Three years later, in 1967, Selikoff published an editorial in the *American Journal of Medicine*, observing that death from pulmonary asbestosis occurred at an earlier age than death from lung cancer, concluding that improved industrial conditions and decreased asbestos exposure was allowing workers to survive long enough to develop lung cancer—statistically significant, if not significantly comforting (Selikoff, Bader, Bader, Churg, & Hammond, 1967). With the evidence mounting, the authors took time to reflect that "Asbestos is a most valuable material, essential in our industrial society. We recognize and study its dangers so that we may devise means of minimizing or avoiding them."

It was the conference on the biological effects of asbestos at the New York Academy of Sciences organized in 1964 that put both mesothelioma and asbestos on the map. The conference provided an examination of the various types of asbestos and the industrial uses of each, as well as the geologic regions in which each of these types was mined, processed, and used in industry. Two key studies were central to the conference discussion, one being Wagner's study of the workers exposed to the Cape Blue crocidolite of South Africa, and the other being Selikoff's examination of morbidity and mortality in New York's Asbestos Workers Union. Although further study was recommended, the response was unbalanced, much of the fervor focused on action to combat one type of asbestos exposure, chrysotile, while overlooking the carcinogenic potential in other types of asbestos fiber (Greenberg, 2003).

During the next several years, discussion ensued over which form of asbestos was most carcinogenic, and by default, which forms, would be less deadly to use. In 1967, Harington suggested that, based on animal experimentation, switching to amosite, although still carcinogenic, "may be a practical and important preventative measure." In 1972, Selikoff published a review of asbestos insulation workers at a plant in New Jersey, noting an increased rate of mesothelioma and lung cancer associated with exposure to the supposedly less deadly amosite. This information was not well received overseas because, as the authors observed, earlier analysis had led to favoring use of amosite in Great Britain. In the United States, the Center for Disease Control and Prevention/National Institute for Occupational Safety and Health and Occupational Safety Health Administration began establishing standards for all asbestos. In the 1980s, the United Kingdom began legislative measures to ban the import and use of crocidolite and amosite, and in 1999 import and use of chrysotile was also banned. By this time, however, millions of workers had been exposed, perhaps as many as 27 million in the United States alone, between 1940 and 1979 (Bartrip, 2004).

Current Status of Asbestos Use in the United States

Mesothelioma and asbestosis rates peaked in the United States around the most recent turn of the century, although the consequences of earlier asbestos exposure are still unfolding. Going forward, there continues to be disagreement regarding the extent to which exposure should or can be limited. In 1989, the US Environmental Protection Agency issued a final rule banning most asbestos-containing products. This rule, however, was vacated 2 years later, and ultimately repealed, although some specific asbestos-containing products remain banned. However, even without the regulatory mandate, many manufacturers and industries began phasing out the use of asbestos voluntarily.

An estimate of the total costs of asbestos litigation in the United States is around 70 billion dollars (Moazzam et al., 2008). This total cost can be divided into defense transaction cost of around 21 billion dollars and gross compensation of around 49 billion dollars. Of the gross compensation of 49 billion dollars, it is estimated that around 19 billion dollars were claimant's transaction cost. Thus, the net compensation for asbestos in the United States was around 30 billion dollars, which is about 42% of total spending. In summary, only 42 cents of every dollar spent on asbestos litigation actually go to asbestos victims. The rest of the money is split between plaintiff and defense attorney fees. Specifically, 31 cents of every dollar goes to defense costs, whereas 27 cents goes to plaintiff attorneys (Moazzam et al., 2008).

Today, most occupational exposures occur during repair, renovation, maintenance, or removal of asbestos-containing products installed years ago. Much of the asbestos used in construction and industry in previous decades remains in place, although considered