Review

Lung cancer from asbestos textured ceilings: a case study

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Background: Asbestos was used in spray applied textured ceilings from 1945 to at least 1980. Exposure to asbestos and the probability of developing lung disease is high in individuals who lived with these types of ceilings in their home. Asbestos exposure and frequency of disease is even higher in an apartment suffering from flooding, maintenance, and/or multiple structural impacts.
Purpose: Our goal is to examine a case of lung cancer in a non-smoking individual exposed to asbestos from the damaged acoustic ceilings in her apartment.
Methods: The subject's medical and occupational records were obtained and reviewed and a physical examination was performed. Exposure ratings were obtained from previous literature for discussion purposes.
Conclusion: Asbestos-textured ceilings are a possible source of asbestos exposure and there may be a risk of developing cancer in individuals exposed to ceiling deterioration.

Keywords: Asbestos, Friable, Textured ceilings, Lung cancer, Water damage, Exposure, Clean air act

Introduction

Asbestos describes a group of naturally occurring fibrous minerals with tensile strength, flexibility, and resistance to heat and chemical degradation.[1] These qualities made asbestos minerals attractive to use in hundreds of building materials (pipe insulation, shingles, floor tile, mastics, roofing, structural steel fireproofing, etc.). Asbestos was also used as a component of spray applied textured ceilings. The use of asbestos and asbestos products has declined in the USA in recent years due to the risks of exposure for workers and others in close proximity. Exposure to asbestos occurs when respirable fibers are released into the air and inhaled. The best way to prevent exposure is to prevent asbestos fibers from becoming airborne, or by wearing proper protection equipment.[2,3] Asbestos is a potent carcinogen that causes all types of cancer including lung cancer and mesothelioma.[4,5] The Environmental Protection Agency (EPA), Occupational Safety and Health Administration (OSHA), Consumer Product Safety Commission, and Mine Safety and Health Administration have enacted laws and regulations for asbestos in the USA.[1] The EPA and OSHA require building owners to inspect their properties for the presence of asbestos before construction, renovation, and demolition activities.[6,7] If asbestos is present, it must be sealed or removed to prevent harmful exposure. This paper presents a case study of a woman with lung cancer and asbestosis as a result of exposure to spray-applied acoustic ceilings. We will demonstrate that exposure and subsequent disease were the result of inadequate risk avoidance and management procedures.

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Asbestos containing textured ceiling materials

Asbestos can be friable and non-friable. Friable indicates that a material can be reduced to powder by hand pressure, during which fibers are released.[8] Working with friable asbestos products requires strict control measures to prevent releasing fibers into the air.[9] Non-friable asbestos must be mechanically impacted (power tools such as sanders, drills, chippers, saws, etc.) to release fibers. Asbestos containing textured ceiling materials (acoustic, popcorn, cottage cheese or more, accurately, stucco ceiling), is a term for a spray-on or paint-on ceiling treatment used from 1945 to 1980 in US residential construction.[10] These ceilings were standard for bedroom and residential hallway ceilings because of its bright, white appearance, noise reduction qualities, and ability to hide imperfections. Asbestos containing textured ceiling is a friable material, making it susceptible to fiber release during any disturbance. Dating back to 1973, the EPA has regulated spray-applied asbestos materials through the National Emission Standards for Hazardous Air Pollutants but the existing inventories of suppliers and installers were exempt.[11] Textured ceilings remain common in residential construction built before 1978 or the early 1980s.

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Case report

Health history

In the early 1990s, the subject began experiencing an intermittent, productive cough. In 2005 she developed a persistent, productive cough. In 2010, she developed severe cough, fever, chills, wheezing, and tightness in the chest and in late 2010, she was diagnosed with metastatic lung cancer. The tumor was resected and a single positive mediastinal lymph node was found. Prior to the lung cancer diagnosis, she had been in good health and reported regular physical activity. She had no history of smoking She was employed as a writer and a model. After developing lung cancer, she had to retire and her physical activity was severely reduced. She developed vertigo, fatigue, and pain in her chest, as well as continuing cough. In late 2012, her doctors noted and removed enlarging lung nodules and the histology is compatible with asbestosis. Neither asbestos bodies nor fibers were counted.

Exposure history

The subject lived in an apartment containing an acoustic ceiling starting in 1982. There were episodes of water intrusion beginning in 1993 and lasting on and off up until 2011. Water intrusion damaged the ceiling, causing it to crumble, sag, and buckle. This intrusion included water leakage from apartments above hers that damaged her acoustic ceiling, leading to visible white dust on flat surfaces and on her clothing. The damaged acoustic ceiling would dry in areas, crumbling and creating dust. This dust coated the entire apartment, including clothing, countertops, tables, lamps, couches, etc. with a fine dust. She described it as "a wool like substance" that got on her clothes, carpeting, and all over the entire apartment due to the landlord's attempts to repair the ceilings and the walls. In total, water damage was reported for more than 18 years

The repairs of the damaged ceiling included sanding the acoustic ceiling creating large amounts of asbestos dust in the apartment. The maintenance crew disposed of the damaged material in the hall in front of her apartment without sealing it. She moved out of the contaminated apartment in late 2012.

Discussion

The subject's first exposure was during the 1980s when she moved into the apartment. Two consulting companies tested the apartment ceiling material in her apartment, garbage, and the hallway, finding asbestos in concentrations from 2 to 6% of the bulk material making up the dust created in the apartment.[12,13] Non-fibrous and non-asbestos material made up the rest of the material measured. The EPA bans spray-applied surfacing asbestos-containing materials that contain more than 1% asbestos.[14] LA Testing, one of the companies, also identified mold in her apartment as the result of repetitive flooding. Water can loosen asbestos making it susceptible to inhalation if it dries and it is not encapsulated immediately. In fact, one recommended technique for removing asbestos is through dampening with water, loosening the material to dispose in leak tight containers.[15] Asbestos abatement and removal contractors are required when completing maintenance and/or construction within an asbestos-contaminated area.[16] In the case of flooding and leaking, contractor use is particularly important because an untrained maintenance worker may not use proper removal techniques and processes to ensure safe handling and cleanup of the material. Ineffective or incomplete procedure can actually do more harm than good, loosening the asbestos for further dispersal over time.

The OSHA permissible exposure limit for asbestos is 0.1 fiber per cubic centimeter of air as an eight-hour time-weighted average.[17] The amount and rate of asbestos exposure in buildings with acoustic ceilings is well over this limit based on the models of "mode of contamination" seen in Sawyer's research.[18] Sawyer determined the average fiber counts per hour range from .02 f/cm^3 during quiet conditions to 17.1 f/cm^3 during heavy ceiling work and removal. A mean of 15.5 f/cm^3 was found during work that required contact with the ceiling. Using transmission electron microscopy, Chadwick et al. found similar quiet condition levels in six public school facilities. The worst case sample taken at undisturbed conditions was 0.739 f/cm^3 (minus ambient levels).

By conservatively using Sawyer's and Chadwick's undisturbed measurements and correcting for the 8-h time weighted average with a 12-h a day average for the amount of time this subject spent in her apartment, we can extrapolate the fiber years for her first 11 years at 0.33 fiber-years and 12.19 fiber-years, respectively. Using the mean fiber count of 5.69 f/ cm^3 for all conditions as measured by Sawyer as well as the subject's additional 18-year exposure to the damaged ceiling, the exposure increases 153.63 fiber-years.

This is likely an underestimation, as Sawyer also reports that exposed and friable ceilings (subject to accidental and capricious contact) gradually deteriorate with even minimal disturbance. He cites air currents, ventilation leaks, and vibrations, shown as constant low-level fallout. These ceilings also suffer from occasional but heavy loss by contact (doors closing, rubbing, bumping into, cleaning, etc.) and frequent re-entrainment or resuspension in the air from contact with dust on surfaces such as floors and tables.

Relative risk of lung cancer increases with cumulative asbestos dose. Gustavsson et al. found that asbestos produced a dose–response relationship with lung cancer, increasing the risk of cancer 14% for each fiber-year.[19] In a later paper, Gustavsson et al. calculated a relative risk of 4.2 (95% CI 1.6–11.1) for never smokers with > = 1.0 fiber-year, rising to 10.2 (95% CI 2.5–41.2) with > = 2.5 fiber years.[20] Previous case studies on spray-installed acoustic ceilings show the correlation between asbestos exposure and lung cancer and mesothelioma.[21–24] These studies are highlighted in Table 1.

Table 1 Building Asbestos Exposure and Cancer

Reference	Case study subjects	Passive exposure in Building	Years exposed	Other exposure (Occupational, shipyard, auto, domestic, neighborhood, etc.)	Findings
Goldberg 2006	***Five campus employees***	***Asbestos insulated building material***		***No other asbestos exposure could be identified, except the sporadic use of asbestos-protecting devices for two of them***	***Mesothelioma likely induced by workplace passive environmental exposure to asbestos-insulated degraded workplaces.***
Case 1	Between 64 to 72-year -old vulcanologist professor	Asbestos insulation	35	None	Pleural plaques in 2000 and mesothelioma in 2002
Case 2	Between 64 to 72-year -old ultrasound physicist	Asbestos insulation	15	None	Pleural plaques and mesothelioma in 2001
Case 3	Between 64 to 72-year -old mathematics professor	Asbestos insulation	29	None	Pleural plaques and mesothelioma in 2001
Case4	Between 64 to 72-year -old paleontology professor	Asbestos insulation	30	None	mesothelioma in 2001
Case 5	Between 64 to 72-year -old oceanography engineer	Asbestos insulation	10	None	Pleural plaques in 1996 and mesothelioma in 2001
Lilienfeld 1991	***Four school teachers***	***Asbestos-insulated building***			***Four cases of malignant mesothelioma in school teachers. Three similar cases in young people (30–45 years) whose only known exposure to asbestos was attendance as pupils at schools with ACM.***
Case 1	60-year-old male school teacher	Acoustic ceiling, pipe insulation and fire protection in school building.	31	Prior radar man in the Navy for 1–2 years	Mesotheliomaencasing the left lung and spreading to lymph nodes and the abdomen.
Case 2	52-year-old male school teacher	Acoustic ceiling (chrysotile-based spray), pipe insulation and fire protection in school building.	25	None	Malignant Mesothelioma. Building sample revealed asbestos concentrations ranging from 2 to 30 percent.
Case 3	43-year-old female teacher	Pieces of the asbestos-containing ceiling would often fall.	21	None mentioned	Malignant Mesothelioma. Ceiling sample revealed chrysotile concentration at 45 percent. 1 percent amosite.
Case 4	64-year-old female teacher	Demolition in adjacent classroom. Continuous exposure.	15	None mentioned	Ovarion Cancer, Malignant Mesothelioma revealed. Analyses of asbestos in the school found 30 to 100 percent chrysotile, and in 2 samples between 50–80 percent amosite.
Schneider 2001					
Case1	46-year-old woman interier designer	Cellar with narrow and low ceilings contained asbestos sprayed ceiling beams	5	None	Indoor exposure to asbestos confirmed by inspection caused pleural Mesothelioma. Low ceiling and narrow rooms susceptible to damage and disturbance.
Stein 1989					
Case 1	54-year-old female office worker	Asbestos Ceilings	Unknown, lifetime office worker	None	Pleural mesothelioma resulting from amosite asbestos. Rapid deterioration consistent with repairs and repaint

The subject of this report was exposed to all modes, frequencies, and rates of exposure. The long-term deterioration of asbestos from water damage in her apartment increased a normal occurrence of fallout, impact, and secondary dispersal, creating an unsafe environment. When asbestos-containing materials (ACM) are disturbed, the asbestos breaks down into very fine fibers. Deteriorating ceiling fibers can become airborne and trapped in lung tissue when inhaled. Asbestos fibers cause lung scarring and eventual cancers, with a latency of 10 to 50 years after initial exposure.[25,26] There is no established safe level of asbestos exposure.[27] Gordon et al. found that it is necessary to test products for smaller fibers using low detection limits to encompass all possible carcinogenic asbestos fibers that are missed with commonly used phase contrast microscopy utilizing either 100 fibers counted or 10 grids examined.[28] Lung cancer and mesothelioma have been found to occur with low-dose exposure in multiple studies and among those whose only exposure was from asbestos-containing building materials.[20,29,30] Asbestos in low concentrations does not necessarily correlate to a lower health risk.

The subject in this case developed typical asbestosis symptoms before being diagnosed with lung cancer. She subsequently was diagnosed with lung scarring consistent with asbestosis. The subject will require ongoing treatment due to increasing scarring and the risk of a second cancer. It is highly recommended that any asbestos-containing material (ACM), most importantly friable ACM, be enclosed, encapsulated and removed by trained professionals to reduce further health damaging exposures.

Conflict of interest

The corresponding author is sometimes retained as an expert in civil cases regarding exposure to asbestos. Original funding for the assessment of the case was provided by law firms representing plaintiffs in a civil lawsuit. The writing of the manuscript was entirely funded by the corresponding author. The law firm was not involved at all in the writing of the report, and it was not written for the purposes of litigation.

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