



Silicosis in denim sandblasters in Turkey

Türkiye’de kot taşlamacılığına bağlı silikozis

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ABSTRACT

Silicosis is a pneumoconiosis caused by the inhalation of crystalline silica. It is the oldest occupational lung disease, but it continues to cause significant morbidity and mortality world wide due to a lack of preventive measures in the workplace. Denim sandblasting silicosis was initially identified in Turkey as a new and unexpected cause of silicosis, and it continues to be reported from other developing countries where denim sandblasting is still taking place. An aggressive form of silicosis was the most common presentation in Turkey reflecting the intense exposure to silica. Many young men have become disabled or have died due to denim sandblasting even though exposure to silica stopped, demonstrating the progressive course of this disease. Unsafe working conditions were the most important contributors in the development of this silicosis outbreak in these workers in Turkey. The aim of this review is to high light the need for occupational hygiene measures to prevent silicosis and to emphasize the importance of the occupational history.

Keywords: Silicosis, denim sandblasting, Turkey

Silicosis is an occupational lung disease caused by the inhalation of respirable crystalline silica dust; it is incurable but 100% preventable by controlling exposure to silica. Silicosis is the oldest occupational lung disease, having been recognized since the times of Hippocrates and the ancient Egyptians, but it continues to cause significant morbidity and mortality worldwide due to inadequate preventive measures in the workplace (1).

Silicosis usually presents with multiple small nodules secondary to the deposition of silica particles in the alveoli and terminal bronchioles. It can evolve into progressive massive fibrosis with a conglomeration of

ÖZ

Silikozis, kristalize silikanın inhalasyonu nedeni ile oluşan bir pnömokonyozdur. Bilinen en eski meslek hastalığı olmasına rağmen, çalışma ortamlarındaki yetersiz önlemlerden ötürü bütün dünyada ciddi morbidite ve mortaliteye neden olmaya devam etmektedir. Kot taşlamacılığına bağlı silikozis, yeni ve beklenilmeyen bir silikozis nedeni olarak ilk defa Türkiye’de tanımlanmıştır ve kot taşlama işçiliğinin devam ettiği diğer gelişmekte olan ülkelere bildirilmeye devam etmektedir. Yoğun silika maruziyetinin bir sonucu olarak agresif silikozis Türkiye’de en sık izlenen silikozis formuydu. Silika maruziyetinin sona ermesine rağmen, pek çok genç erkek hasta, hastalığın ilerleyici seyirinden dolayı kot taşlamacılığı silikozisine bağlı olarak ölmekte ya da engelli kalmaktadır. Türkiye’deki bu işçilerde silikozisin patlak vermesindeki en önemli unsur, güvenli olmayan çalışma koşullarıydı. Bu derlemenin amacı, mesleki hijyen koşullarının sağlanmasının gerekliliğinin ve meslek öyküsünün önemini altını çizmektir.

Anahtar Kelimeler: Silikozis, kot taşlamacılığı, Türkiye

these nodules in the workers with prolonged and intense exposures. There are three types of silicosis, depending on the severity and duration of exposure to crystalline silica: chronic or classic, accelerated, and acute. Chronic silicosis is the most common form and generally develops after exposure over decades. Acute and accelerated silicosis are aggressive forms of silicosis and are caused by more intense silica exposure. These aggressive forms can progress to respiratory failure and death within a short period of time (several months to years) after the initial exposure. In many workers the intensity of silica exposure is unknown, and the disease course is not apparent until follow-up studies become available.

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Hazardous occupational exposures to silica occur in a variety of industrial operations, including mining, rock drilling, road construction, tunneling operations, and sandblasting. Periodically disease clusters occur in industries which should be aware of the hazards associated with silica (2). In addition, new and unexpected exposures can occur, and denim sandblasting in the textile industry in Turkey provides an excellent example of an old disease occurring in a new population of workers. This review article summarizes the information available on the silicosis outbreak in denim sandblasters in Turkey to highlight the need for industrial safety measures to prevent silicosis and to emphasize the importance of the occupational history in recognizing traditional as well as emerging occupational and environmental diseases. In addition, these cases draw attention to the unexpected consequences of changes in the workplace secondary to changes in commercial activities in industries not typically associated with industrial hazards and demonstrate that mundane choices such as a preference for faded jeans can have important health consequences in workers.

MATERIALS and METHODS

The medical literature was searched using PubMed using the MeSH terms silicosis and Turkey and the text terms sandblasting and denim and jeans. The reference lists from relevant articles were also reviewed to identify articles not indexed in PubMed. Articles were limited to English and Turkish language publications.

DISCUSSION

Denim sandblasting is an abrasive process of projecting sand on denim to soften the fabric and provide a more worn and faded look. It is the preferred technique to create fashionable worn-out jeans because it is quicker and cheaper than other methods, such as the use of sandpaper or brushes, chemical treatment, or laser technology. Turkey was one of the largest world exporters of the sandblasted jeans in the 2000s. This commercial process started in Turkey in the 1990s and reached its peak in the early 2000s when worn-out or pre-torn jeans became trendy globally (3). Denim sandblasting was performed manually in many small-scale workshops, mostly located in Istanbul, until it was banned in 2009. Quartz is the most common form of crystalline silica, and it was the most widely used abrasive sand in denim sandblasting since it is cheap and readily available in Turkey (4).

The first cases of denim sandblasting silicosis in Turkey were diagnosed in the beginning of the 2000s (5-7). These patients reported working in the textile industry, and silicosis was not suspected as an explanation for

their symptoms. These cases had an initial diagnosis of tuberculosis or sarcoidosis, but open lung or transbronchial biopsy demonstrated histological changes consistent with silicosis. The typical histology includes alveolar lipoproteinosis (acute silicosis), silicotic nodules (classic or chronic silicosis) and mixed pathology (accelerated silicosis). Silica particles are only weakly birefringent, and patients with nonspecific histological changes or patients involved in litigation may need more sophisticated testing with electron microscopy and energy dispersive X-Ray analysis to identify the silica particles (8). The first two cases reported by Akgun had silicotic nodules with lipoproteinaceous material in the alveoli (case 1) and alveolar lipoproteinosis with chronic inflammation (case 2) (5). After the diagnosis of the first cases, the medical community in Turkey became more aware of this novel source of silicosis, and subsequent cases were diagnosed using the occupational history and chest radiography without the need for more investigation. The number of cases dramatically increased in the following years after these initial cases were identified (9-12).

Although chronic or classic silicosis is the most common clinical form in other worksites, during the silicosis outbreak in denim sandblasters in Turkey, aggressive forms of silicosis were the most common presentation. Between 2005-2009, most of the cases presented with acute silicosis reflecting the extremely high exposure to respirable crystalline silica (5-7,9-12). Akgun et al studied 157 former denim sandblasters. All the workers were men with a mean age of 23 years (range: 15-44 years) who had worked for 36 months (mean, range: 1-120 months) in small workshops using sandblasting to fade denim jeans (3). Progressive shortness of breath, chest pain, fatigue, and weight loss were the most common symptoms at presentation, which could begin within a few months after the initial exposure. Deaths due to respiratory failure were also reported in these sandblasters due to acute silicosis. The details of acute silicosis case reports are given in Table 1. The number of new acute silicosis cases has probably decreased with the prohibition of denim sandblasting in 2009, but many former sandblasters continue to suffer from accelerated and chronic form of silicosis even after exposure stopped.

Silicosis-associated deaths in developed countries have decreased significantly in the last decade with the effective control of crystalline silica exposure in the workplace. For instance, the annual number of silicosis-associated deaths declined from 164 (death rate= 0.74 per 1 million population) in 2001 to 101 (death rate= 0.39 per 1 million) in 2010 in United States (13). Mortality and

Table 1. Details of case reports with acute silicosis in denim sandblasters in Turkey

	Reason for missing treatment
Akgun M et al (5).	Two concomitant cases from the same workplace in Istanbul; age at presentation 18 and 19 years. Patients started sandblasting at ages 13 and 14. Presenting symptom progressive dyspnea. Diagnosed with open lung biopsy. Both patients died 4 and 9 months after diagnosis due to respiratory failure ⁽⁹⁾ .
Akgun M et al (9).	Sixteen cases of silicosis. History of working as denim sandblasters in Istanbul. Mean age at presentation 23 ± 6 years. Mean duration of exposure to silica 3.0 ± 2.2 years. Theage at first silica exposure 17 ± 6 years. Mean weekly days at work 6.0 ± 0.5 day/week, and mean daily work hours 9.7 ± 8.2 h/day.
Sahbaz S et al (11).	Two acute silicosis cases caused by denim sandblasting from Tokat, Turkey. Same working place, ages 23 and 25, Duration of exposure to silica 3 and 1.5 years Presenting symptom shortness of breath and hemoptysis

morbidity due to silicosis in developed countries generally appear during the later decades of life due to chronic silicosis. Unfortunately, aggressive potentially fatal forms of silicosis continue to be reported from developing countries where labor is cheaper and proper regulatory guidelines may be lacking. Sevinc et al investigated the working environment and conditions of five small-scale sandblasting workshops in Izmir, Turkey; the respirable dust concentration containing free silica was 76 mg/m^3 , which is 300 times more than the permitted level of 0.25 mg/m^3 (4). Also, it was noted that none of the workplaces had sufficient local exhaust ventilation and that the workers were not using effective respiratory protective equipment (4). Other reports also highlighted the poor working environment in small workplaces without any respiratory protection and prolonged work hours (3,14). These unsafe and unhealthy working conditions leading to intense exposure to respirable crystalline silica were the main contributors to the silicosis outbreak among denim sandblasters in Turkey.

Many formerly healthy young denim sandblasters have become disabled or have died due to acute or accelerated forms of silicosis in Turkey within 3-5 years of initial exposure, even though their exposure did not continue. The Turkish medical community had a crucial role in recognizing the outbreak of aggressive silicosis among denim sandblasters and the prohibition of denim sandblasting. The Turkish government also provided free healthcare access to denim sandblasters with silicosis since many of the workers did not have health insurance and were no longer able to work. After the prohibition

of denim sandblasting in Turkey, some industries have shifted their business to other developing countries, including Bangladesh and India (15,16).

Prevalence

The number of workers exposed to crystalline silica in Turkey is unknown since most of the sandblasting workshops were unregistered and/or their employees worked without formal contracts. Although there are no official data, more than 5000 workers may have silicosis (17). Cross-sectional studies performed in local areas have estimated the prevalence of silicosis in former denim sandblasters (3,18). Akgun et al. showed that 53 percent of former denim sandblasters had the radiologic evidence of silicosis on chest-X Rays according to the International Labour Office (ILO) classification (3,19). In another study using multidetector computed tomography, 74% of former denim sandblasters had radiologic evidence of silicosis (18). The details of these cross-sectional studies are given in Table 2. Akgun et al recently published four-year follow-up data on denim sandblasters and reported an increased prevalence of disease during follow-up even though exposure had stopped (20). The prevalence of silicosis in 83 former denim sandblasters increased from 60.2% (50/83) in 2007 to 96.4% (80/83) in 2011, reflecting the inevitable course of silicosis even after exposure to silica ends (20).

Natural History

The progressive course of denim sandblasting silicosis has been reported in two follow-up studies (14,20). Bakanet al.(14) reviewed the clinical outcomes of 32 formerly healthy male patients diagnosed with

Table 2. Details of cross sectional studies former denim sandblasters in Turkey

	Reason for missing treatment
Akgun M et al (5).	<p>Cross-sectional study from Erzurum, Turkey</p> <p>154 former denim sandblasters (all male) with a mean age of 23 (15-44) yrs.</p> <p>Most subjects had started working in sandblasting before the age of 20 years</p> <p>Mean total duration of work in sandblasting 36 (range 1-120) months</p> <p>Mean time period after the last exposure was 43 (range 10-144) months.</p> <p>Most subjects (83%) had respiratory symptoms, particularly dyspnea (52%).</p> <p>Radiological evidence of silicosis (ILO score 1/0 or higher) was found in 77/145 subjects (53%) with interpretable chest radiographs.</p> <p>Affected subjects had lower FEV₁ and FVC</p> <p>Seniority (i.e. working as a foreman), duration of exposure, and the number of work places correlated with the risk of silicosis.</p>
Ozmen CA et al (18).	<p>Cross-sectional study from Diyarbakir, Turkey</p> <p>60 former denim sandblasters with a mean age of 26.0 ± 5.5 years (range, 17-43 years)</p> <p>History of exposure to silica varying between 2-60 months (18.5 ± 18.4 months).</p> <p>Mean latency period (time between initial exposure and radiological imaging) 7.3 ± 1.6 years (range 5-13 years)</p> <p>Silicosis diagnosed by X-Ray in 44/60 (73.3%)</p> <p>The latency period and duration of silica exposure was longer in patients diagnosed with silicosis than in those without silicosis (p< 0.05).</p> <p>All cases of silicosis were clinically classified as accelerated, and 11.4% had progressive massive fibrosis.</p>

FEV₁: Forced expiratory volume at 1 second, FVC-forced vital capacity.

denim sandblasting silicosis between 2001 to 2009; the median follow-up duration was 29 months. The majority of patients was diagnosed with acute silicosis and accelerated silicosis based on the exposure period and the clinical presentation. Six patients (19%) died (mean age at death 35); four had acute silicosis and two had accelerated silicosis. During the follow-up, pulmonary function tests, including forced vital capacity (FVC), forced expiratory volume in the first second (FEV₁), diffusion capacity of lung for carbon monoxide (DLCO), dropped in patients with acute and accelerated silicosis; the DLCO decreased in patients with chronic silicosis (14). In four-year follow-up study reported by Akgun, which includes 83 male denim sandblasters, nine patients (6.2%) died at a mean age of 24 years. Only one patient among the 74 survivors had no progression on chest X-Ray or pulmonary function. Radiological progression and pulmonary function loss was observed in 82% and 66% of the cases during the follow-up, respectively (20). The details of these studies are given in Table 3.

Other Medical Disorders

Silicosis is the most commonly associated disease with silica exposure; in addition to silicosis, exposed workers are also at risk to develop other medical problems, including chronic obstructive pulmonary disease, lung cancer, tuberculosis, connective tissue disease, and kidney disease (21-25). High rates of depression and anxiety, tuberculosis,

upper airway pathologies, including adenoid vegetation and rhinitis, and eye pathologies, such as pinguecula and conjunctival hyperemia, have been reported in Turkish denim sandblasters (26-28). Secondary spontaneous pneumothorax in acute and accelerated forms of silicosis has also been reported (29, 30).

CONCLUSION

Denim sandblasting silicosis is a novel occupational disease first identified in Turkey; many workers have become disabled and/or have died in the early decades of life. Increased awareness of denim sandblasting silicosis has led some companies to implement denim sandblasting bans, and use alternative methods to create a worn look in denim. Denim sandblasting is still taking place in other developing countries, including Bangladesh, China, and India (15,16). It is difficult for consumers to make a conscious choice since it is not easy to differentiate manually sandblasted jeans from jeans that have been treated using other methods. Campaigns to increase the public's awareness of denim sandblasting silicosis proscribe buying any worn-out clothes to end denim sandblasting globally. Physicians need to consider occupational and environmental exposures in all patients with unexplained complaints. The patient in your office may be the sentinel case for a cohort of at risk workers.

Table 3. Details of follow-up studies in former sandblasters in Turkey

	Reason for missing treatment
Bakan ND et al (14).	<p>32 male patients (median age 31.5 years) diagnosed with denim sandblasting silicosis between 2001-2009.</p> <p>Median follow-up 29 months (range 3-101 months).</p> <p>Mean total duration of work in sandblasting 66.4 h/wk for a median 28.5 months.</p> <p>Mean cumulative exposure time to silica was 12,957 h.</p> <p>Median latency period (time between initial exposure and diagnosis) 5.5 years (range 2-14 years).</p> <p>26/32 patients had respiratory symptoms; 6/32 asymptomatic.</p> <p>10 patients (31.3%) had acute silicosis, 20 patients (62.5%) had accelerated silicosis, and 2 patients (6.3%) had chronic silicosis.</p> <p>6/32 patients (19%) died from progressive massive fibrosis.</p> <p>4/10 patients (40%) with acute silicosis died.</p> <p>2/20 patients with accelerated silicosis (10%) died.</p> <p>Time to death after initial exposure: 6.4 years in acute silicosis, 9.4 years in accelerated silicosis patients.</p> <p>The median survival 78 months.</p> <p>Estimated 5-year survival 69% for denim sandblasters with silicosis.</p>
Akgun M et al (20).	<p>83 male patients with denim sandblasting silicosis four-year follow up</p> <p>9/83 (6.2%) died at a mean age of 24 years.</p> <p>Prevalence of silicosis increased from 55.4% to 95.9% in 74 living sandblasters.</p> <p>Radiographic progression, defined as a profusion increase of two or more subcategories, development of a new large opacity, or an increase in large opacity category, observed in 82%.</p> <p>Pulmonary function loss, defined as a 12% or more decrease in forced vital capacity seen in 66%.</p> <p>Mortality risk factors included: never smoking, foreman work, number of different denim sandblasting places of work, sleeping at the workplace, and lower pulmonary functions.</p>

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