Chronic Silicosis as the Potential Consequence of Short-Term Exposure to Silica: A Case Report

Kanruethai Tangsurased[1] ; Narongpon Dumavibhat[2] ; Supakorn Chansaengpetch[2] ; Tirathat Virojskulchai[2] ; Sitthiphon Bunman[3] ; Thammasin Ingviya[1] ; Apinut Jaroonpipatkul[2] ; Thanet Thampibal[4] ; Sangjan Hathaivasiwong[4] ; Sutatip Buranasatitnon5; Tadsaphorn Phookjit[5] ; Oranut Srihadom[5] ; Natthawoot Oysrisakul[6]

Kanruethai Tangsurased

[1] Department of Family Medicine and Preventive Medicine, Faculty of Medicine, Prince of Songkla University, Songkhla, Thailand.
[2] Department of Preventive and Social Medicine, Faculty of Medicine Siriraj Hospital, Mahidol University, Thailand
[3] Department of Community and Family Medicine, Faculty of Medicine, Thammasat University, Pathum Thani ,Thailand
[4] Department of Occupational Medicine, Suratthani Hospital, Surat Thani, Thailand
[5] Division of Occupational and Environmental Diseases, Department of Disease Control, the Thai Ministry of Public Health, Nonthaburi, Thailand.
[6] Wellness and Occupational Medicine Center, Bangkok Hospital Hatyai, Songkhla,Thailand.

*Address Correspondence to author:
Narongpon Dumavibhat, MD, PhD
Department of Preventive and Social Medicine,
Faculty of Medicine Siriraj Hospital, Mahidol University
2 Wanglang Road, Bangkok Noi,
Bangkok 10700, Thailand
email: dumavibhat@yahoo.com

Received: October 19, 2023
Revision received: December 05, 2023
Accepted after revision: December 12, 2023
BKK Med J 2024;20(1): 29-32.
DOI: 10.31524/bkkmedj.2024.12.001
www.bangkokmedjournal.com

Abstract

Silicosis is an irreversible occupational lung disease caused by inhaling respirable crystalline silica. Silicosis poses a major public health challenge worldwide. The International Labour Organization (ILO) and the World Health Organization (WHO) have established a program to eliminate silicosis by 2030. However, despite these efforts, silicosis cases are still rising and reemerging in various industries and sectors. The authors report a case of chronic silicosis with a history of short-term silica exposure in a mining worker in Nakorn Sri Thammarat province, Thailand. The patient later developed progressive dyspnea and an abnormal chest radiograph. At present, the patient is undergoing supportive treatment, and his clinical symptom has been stable. This case study aims to raise awareness regarding the potential risks of chronic silicosis associated with relatively short-term duration of respirable crystalline silica exposure.

Keywords: silicosis, pneumoconioses, occupational lung diseases, short-term exposure, silica

Silicosis is an occupational pulmonary disease caused by inhaling respirable crystalline silica. It is an incurable and burdensome disease but entirely preventable.[1] The global incidence has been increasing in recent decades, leading to the initiation of a public awareness and prevention program by the World Health Organization (WHO) and the International Labor Organization (ILO) in 1995, which aimed at eliminating silicosis by 2030.[2] Globally, the number of reported silicosis cases has increased by 64.6%, from 84,821 cases in 1990 to 138,965 cases in 2019.[3] The ongoing increase in silicosis cases can be attributed to a lack of awareness, unsafe practices, and inappropriate health surveillance. According to the Health Data Center (HDC) of the Thai Ministry of Public Health, there were 235 reported cases of silicosis in 2022, or 0.51 per 100,000 population, with the highest incidence observed in ages over 60.[4]

This case study demonstrated a case of chronic silicosis in a mining worker in Nakorn Sri Thammarat, a province in Southern Thailand, who developed the disease despite an unusually short but significant exposure to respirable crystalline silica. Additionally, this study addresses the importance of occupational health surveillance and the implementation of effective preventive measures for the benefit of workers, employers, and public health.

The 2011 ILO Classification of Radiographs of Pneumoconioses (ILO/ICR[5])

The 2011 ILO/ICRP describes small opacities and profusion in detail elsewhere.[5] In brief, the small round opacities are categorized by diameter size up to 1.5 mm into p, 1.5 to 3 mm into q, and 3 to 10 mm into r. The small irregular opacities are classified by size into s, t, and u, using the same width ranges as small round opacities. The profusion of small opacities is categorized into four major scales: 0, 1, 2, and 3. Each major scale is subscale into three minor scales, giving twelve categories of profusion 0/-, 0/0, 0/1, 1/0, 1/1, 1/2, 2/1, 2/2, 2/3, 3/2, 3/3, and 3/+ respectively.

Case Report

A 64-year-old Thai male worked in the Wolfram mining industry at Khao Soon, Nakorn Sri Thammarat, for five months back in 1973. His job title was to crush stones using a millstone machine, where the stone-crushing process involved controlling the transfers of stones in and out of the millstone machine. The patient reported that dust had spread across both their body and the surrounding work area. He worked without proper personal protective equipment and control measures for stone dust emission. His workdays were eight hours a day, seven days a week, and he resided in the factory's accommodation near the working area. Interestingly, the patient stated that his colleagues who worked in the same mine had passed away from lung diseases after working for a few years. Subsequently, he changed his job to a general construction worker for 44 years, performing various tasks such as bricklaying, concrete and tile cutting, paving, operating a cement mixer, and finishing and demolition work. Throughout this long period, he still lacked proper protective measures. The patient had smoked with a cumulative exposure of 15 pack-years and ceased smoking for five years. He denied significant past medical illnesses; however, he had never undergone an annual physical examination or chest radiograph.

Approximately five years ago, the patient began to experience progressive dyspnea. He initially consulted a primary care physician and underwent chest radiography, revealing abnormalities, as shown in Figure 1. Subsequently, he continued his care in the internal medicine department and was later referred to an expert for a diagnosis of silicosis. A National Institute for Occupational Safety and Health (NIOSH) certified B reader confirmed these chest radiographic abnormalities to be compatible with silicosis classified as q/q 2/1, in terms of small opacity and profusion, respectively, accompanied with eggshell calcification of lymph nodes at bilateral hilar and paratracheal areas according to the 2011 ILO/ICRP. In addition, his spirometric results showed a very severe non-reversible airflow obstruction. The FEV1/FVC ratio was 38%, with predicted FEV1 and FVC values at 25% and 53%, respectively. Currently, the patient is undergoing supportive treatment, including the use of a long-acting bronchodilator.

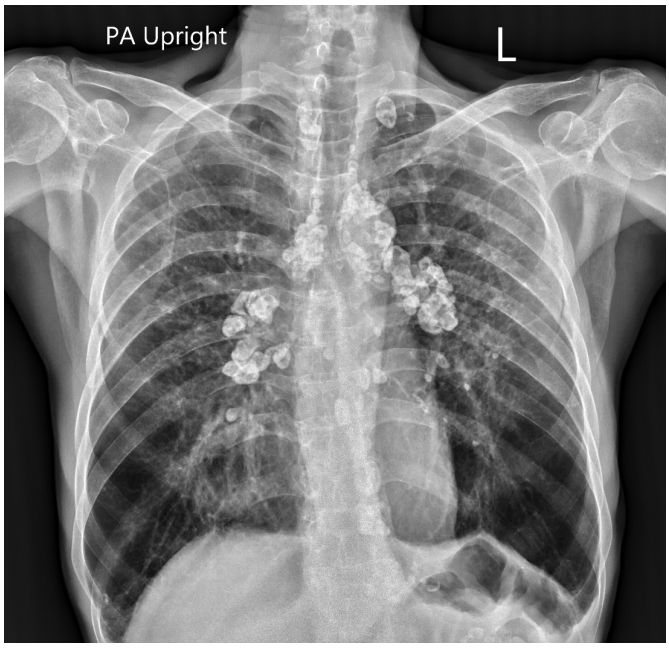

Figure 1: The patient's posterioanterior (PA) chest adiograph demonstrated diffused nodular infiltration, predominantly affecting upper and mid-lung zones in both lungs. Calcifications of lymph nodes were also evident in both the hilar and paratracheal regions.

Discussion

Silicosis is an incurable disease and it can progress even without further silica exposure. A prior study found radiologic evidence of progression in Japanese tunnel workers who had been removed from silica exposure, with an average time of progression exceeding 15 years.[6] Chronic silicosis is the most common form, resulting from long-term exposure of ten years or more on average.

Chronic silicosis patients typically remain asymptomatic until the disease advances.[6,7]

In this study, we presented a case of chronic silicosis with an occupational history of relatively short-term but significant silica exposure, namely five months, primarily from stone crushing. Nonetheless, the patient remained exposed to silica

ISSN 2287-0237 (online)/ 2228-9674 (print)

after transitioning to construction work. The patient was later diagnosed with chronic silicosis and proceeded to the consultation of a pulmonologist, an expert at the Workmen's Compensation Fund, the Social Security Office, and the Thai Ministry of Labour. Moreover, the diagnosis in this case was also verified by designated panelists. There are three types of silicosis, categorized based on the duration of exposure and symptoms of the disease:

1. Acute silicosis.
2. Accelerated silicosis.
3. Chronic silicosis.

Acute silicosis is caused by exposure to very high levels of silica over a short period, leading to the development of symptoms within weeks or months. Symptoms of acute silicosis comprise cough, dyspnea, fever, and weight loss. Those with acute silicosis often result in respiratory failure and, eventually, death. Radiographic findings of acute silicosis show diffuse alveolar opacities, entirely distinct from the other two types of silicosis.

Accelerated silicosis develops after exposure to high levels of silica for at least two years and typically occurs within ten years. Exertional dyspnea and cough are common symptoms, and its chest radiographic features are diffused nodular infiltration. In contrast, patients with chronic silicosis are mostly asymptomatic and are frequently diagnosed incidentally through abnormal chest radiographs, e.g., during health surveillance or for other purposes.

Chronic silicosis usually follows exposure to silica over five years, commonly over ten years. Radiographic findings of chronic silicosis are similar to the accelerated form, showing diffuse nodular opacities. Notably, they may accompanied by eggshell calcifications of intrathoracic lymph nodes.[8] The presence of these findings should prompt physicians to consider silicosis as part of the differential diagnosis, particularly in those with a history of silica exposure.

In Thailand, diagnosis of silicosis is based on the following criteria:

1. A history of silica exposure for at least two years.
2. A chest radiograph with profusion 1/0 or greater according to the 2011 ILO/ICRP.
3. Pathological lung biopsy evidence or epidemiological evidence.

At least 2 of 3 are fulfilled to diagnose silicosis.[9] This patient was diagnosed with silicosis through evidence of consistent radiographic findings and a history of silica exposure, primarily during five months of stone crushing in the mining industry. Theoretically, short-term high-level silica exposure is frequently related to acute or accelerated silicosis with associated symptoms.[10,11] However, this patient had a history of short-term exposure but did not complain of any symptoms over the past four decades. Remarkably, his clinical and radiographic manifestations all pointed to chronic silicosis. Still, apart from the significant exposure due to stone crushing, this patient might be exposed to silica from the construction activities. Occupational Safety and Health Administration (OSHA) estimated that around 100,000 workers were potentially exposed to silica at or above the NIOSH Recommended Exposure Limits (RELs) in 2014, with the majority (79%) working in the construction industry. Among the industries, tile and terrazzo contractors (12%), brick, stone, and related construction merchant wholesalers (10%), masonry contractors (6%), and poured concrete foundation and structure contractors (6%) demonstrated the highest percentages of workers potentially being overexposed.[12] Nevertheless, it is noteworthy that there are few reports of silicosis among construction workers, considering the substantial size of the workforce in this sector globally. Data from Michigan, New Jersey, and Ohio, USA, from 1993 to 2002 showed that silicosis cases in the construction sector accounted for 42 (9%), 24 (17.8%), and 15 (5.4%), respectively. According to the same report, silicosis cases in other occupations (i.e., transportation, finance, and public administration) were also disclosed(13). Therefore, some of the documented cases, including those within the construction sector, may have had exposure to silica during their previous higher-risk jobs.

Furthermore, there have been no reported cases of silicosis among construction workers in Thailand, as well as in many other countries. To our knowledge, the industries most commonly at risk for silicosis include mining, tunneling, sandblasting, quarrying, and foundries.[14–16] In this patient, from our point of view, the significance of silica exposure thereby remains likely to be linked to stone operation. Consequently, we propose that chronic silicosis in the presented case is primarily attributed to an unusually short period of silica exposure in the mining industry.

Regarding his clinical progression, the patient began to develop dyspnea five years ago, probably due to the late stage of chronic silicosis and/or chronic obstructive pulmonary disease (COPD), as these two diseases can coexist.[17] His spirometry findings showed a very severe irreversible airflow obstruction, whereas, in silicosis, spirometry findings may display either an obstructive, restrictive, or combined pattern. In contrast, COPD typically exhibits an obstructive pattern.[8,17] As a result, combining the patient's history of smoking, the presence of COPD in this patient could be influenced by both silica exposure and smoking.

This case study represents an emerging report of a chronic silicosis case associated with a relatively shorter duration of silica exposure. Future observations and studies are required to verify the premise. Concerning the aim of ILO and WHO to eliminate silicosis by 2030, primary prevention is the best strategy. Examples include alternative use of silica, exhaust system, water spraying system, and adequate personal protective equipment combined with effective law enforcement. Specifically, appropriate personal protective equipment includes a respirator with a proper filter for silica, as well as goggles and gloves.[16] Together with primary prevention, secondary prevention (i.e., occupational health surveillance)

also plays a crucial role in the early detection of such. Significantly, cooperation among stakeholders is needed for the successful elimination of silicosis.

Limitations in the present case study should be considered. First, there is the potential for misinformation regarding the provided exposure and occupational history. Second, data on the concentration and levels of silica are lacking. However, many stone miners working in this area developed silicosis underlined the significant silica exposure, which was a reason why the cabinet decided to close the area permanently in 1981.[18]

Conclusion

We presented a case study highlighting chronic silicosis in a mining worker with a short-term but significant history of silica exposure. This observation demonstrated the potential occurrence of chronic silicosis, even following a short duration of exposure, which warrants careful attention and further investigations.

Statement of Ethics

This study protolcol was reviewed and approved by the Human Research Ethics Committee of Thammasat University (Medicine) (225/2023). A written informed consent was obtained from the subject for publication of their details and any accompanying images.

Acknowledgements

We would like to express our gratitude to Mr. Prapatsorn Chewsuwan and Miss Phattinan Jinnawong, Donsak District's public health officers for their support in completing this case study.

References

1. Mandrioli D, Schlünssen V, Ádám B, et al. WHO/ILO work-related burden of disease and injury: Protocol for systematic reviews of occupational exposure to dusts and/or fibres and of the effect of occupational exposure to dusts and/or fibres on pneumoconiosis. *Environ Int* 2018;119:174–85. doi: 10.1016/j.envint.2018.06.005.
2. The Lancet Respiratory Medicine. The world is failing on silicosis. *Lancet Respir Med* 2019;7(4):283. doi: 10.1016/S2213-2600(19)30078-5.
3. Liu X, Jiang Q, Wu P, et al. Global incidence, prevalence and disease burden of silicosis: 30 years' overview and forecasted trends. *BMC Public Health* 2023;23(1):1366. doi: 10.1186/s12889-023-16295-2.
4. Ministry of Public Health. Health Data Center HDC. Silicosis case report in 2022. [Internet]. (Accessed 2023 July 29, 2023 at https://hdcservice.moph.go.th/hdc/reports/report.php?source=envocc/format1.php&cat_id=f16421e617aed29602f9f09d951cce68&id=39b969f3d3eac09dd372c2258dc6c232).
5. International Labour Office, editor. Guidelines for the use of the ILO international classification of radiographs of pneumoconioses. Revised edition 2011. Geneva: International Labour Office; 2011.
6. Dumavibhat N, Matsui T, Hoshino E, et al. Radiographic progression of silicosis among Japanese tunnel workers in Kochi. *J Occup Health* 2013;55:142-8. doi: 10.1539/joh.12-0258-oa.
7. Yates DH, Johnson AR. Silicosis and other silica-related lung disorders. In: Occupational and environmental lung disease. *Eur Respir Monogr* 2020;89:150-75. doi:10.1183/2312508X.10034819
8. Dumavibhat N, Chansaengpetch S, Virojskulchai T, et al. Occupational diseases: silicosis. In: Buranatrevedh S, editor. Guidelines for surveillance and investigation of occupational diseases and environmental diseases under occupational diseases and environmental diseases control Act B.E.2562 (A.D.2019). Bangkok: Aksorn Graphic and Design Publishing House; 2023:31-52.
9. Youngchaiyud P, Dumavibhat N. Evaluation of pulmonary impairment. In: Manual for assessing permanent impairment, electronic edition 2022. Bangkok: Saengchan printing Ltd.;2022:593-622.
10. Nowak-Pasternak J, Lipińska-Ojrzanowska A, Świątkowska B. Silicosis after short-term exposure. *Occup Med (Lond)* 2023;73(1):33-5. doi: 10.1093/occmed/kqac113.
11. Nakládalová M, Štěpánek L, Kolek V, et al. A case of accelerated silicosis. *Occup Med (Lond)* 2018;68(7):482-4. doi: 10.1093/occmed/kqy106.
12. Doney BC, Miller WE, Hale JM, et al. Estimation of the number of workers exposed to respirable crystalline silica by industry: analysis of OSHA compliance data (1979-2015). *Am J Ind Med* 2020;63(6):465–77. doi: 10.1002/ajim.23109
13. Centers for disease control and prevention, National institute for occupational safety and health. Silicosis: primary industries associated with silica exposure of silicosis cases by state, 1993-2002. [Internet]. 2023 (Accessed October 15, 2023, at https://wwwn.cdc.gov/eWorld/Data/445. 2023.).
14. Leung CC, Yu ITS, Chen W. Silicosis. *Lancet* 2012;379(9830):2008-18. doi: 10.1016/S0140-6736(12)60235-9.
15. Akgün M, Ergan B. Silicosis in Turkey: Is it an Endless Nightmare or is There Still Hope? Turk Thorac J 2018;19(2):89-93. doi: 10.5152/TurkThoracJ.2018.040189.
16. Rupani MP. Challenges and opportunities for silicosis prevention and control: need for a national health program on silicosis in India. J Occup Med Toxicol 2023;18(1):11. doi: 10.1186/s12995-023-00379-1.
17. Fan Y, Xu W, Wang Y, et al. Association of occupational dust exposure with combined chronic obstructive pulmonary disease and pneumoconiosis: a cross-sectional study in China. *BMJ Open* 2020;10(9):e038874. doi: 10.1136/bmjopen-2020-038874.
18. Wikipedia. Khao Soon. [Internet]. 2022 . (Accessed 2023 October 15, 2023 at https://th.wikipedia.org/wiki/%E0%B9%80%E0%B8%82%E0%B8%B2%E0%B8%A8%E0%B8%B9%E0%B8%99%E0%B8%A2%E0%B9%8C).