American Journal of Medical Sciences and Medicine, 2019, Vol. 7, No. 3, 60-63
Available online at http://pubs.sciepub.com/ajmsm/7/3/2
Published by Science and Education Publishing
DOI:10.12691/ajmsm-7-3-2

Silicosis: Origins and Consequences

Diemen Delgado Garcia[1,*], Patricio Rivera Latorre[2], Nayab Mahmood Sultan[3], Oscar Ramirez Yerba[4], Enmanuel Agila Palacios[5], Ashley Delgado Cano[6]

[1]University of Guadalajara, Researcher, Research Institute for Safety and Health at Work, Guadalajara, Mexico
[2]University of Chile, Professor of Chemistry, Faculty of Sciences, Santiago, Chile
[3]Silicosis Research, Technical Program Lead, Vancouver, Canada
[4]Scientific University of the South, Researcher of the Postgraduate of Occupational Medicine and the Environment, Lima, Peru
[5]University of the Armed Forces of Ecuador, Faculty of Security and Risks, Quito, Ecuador
[6]Universidad Andres Bello, Medical student, Viña del Mar, Chile
*Corresponding author: airnpeumoamericalatina@gmail.com

Received July 26, 2019; Revised September 05, 2019; Accepted September 10, 2019

Abstract Silicosis is a lung disease caused by the inhalation of silica dust and the consequent depositing of this inorganic material in the bronchi, lymph nodes, and/or lung parenchyma, with or without, associated respiratory dysfunction. Silicosis is an irreversible disease. Chest digital radiography is considered as one of the greatest technological advances in imaging systems beneficial in the identification of Silicosis. The diagnostic basis of silicosis is the radiological finding of diffuse lung opacities, associated with the history of inhalation of silica dust or one of its several polymorphs. Occupational history forms a major component in the investigation process along with the finding of diffuse pulmonary nodules. The application of adequate dust control measures in work environments allows workers to prevent or control exposures thus avoiding or limiting the potential for the disease. Among the challenges of how we should address this public health problem, is to raise awareness among key stakeholders engaged in the working environment about the magnitude of the health problem caused by Silicosis.

Keywords: *silica, silicosis, radiology, prevention*

Cite This Article: Diemen Delgado Garcia, Patricio Rivera Latorre, Nayab Mahmood Sultan, Oscar Ramirez Yerba, Enmanuel Agila Palacios, and Ashley Delgado Cano, "Silicosis: Origins and Consequences." *American Journal of Medical Sciences and Medicine*, vol. 7, no. 3 (2019): 60-63. doi: 10.12691/ajmsm-7-3-2.

1. Brief History – Silicosis

There is a general misconception among various practitioners involved in both health, medicine and safety-related disciplines that the concept of Silicosis is a new or emerging disease however this is not so. Various famous medical and scientists have referred to conditions that would eventually go onto have the name Silicosis. The actual term '*silicosis*' was coined by pneumologist Achille Visconti in 1870.

There are various references in historical texts relating to respiratory ill health such as Hippocrates.

Although the harmful effects of breathing polluted air were already known, Silicosis which is an irreversible, pulmonary fibrosis disease is considered particularly disabling and a recognized occupational disease in many countries. It is a very common disease in miners [1].

Since ancient times and until mid-twentieth century, it was common for miners to suffer from a condition 'Miners' Consumption'. For many years this remained unclear of what caused the disease, and why this did not seem to affect other workers. Later, the relationship between the disease and the dust found in the workplace was established. After analyzing its contents, it was discovered that the direct cause of the disease was the crystallized silicon dioxide (SiO_2), called silica, which gave it its current name of Silicosis [2].

2. Body

Silicosis a lung disease caused by the inhalation of silica dust and is considered to be a biologically active dust and the consequent deposition of inorganic solid waste in the bronchi, lymph nodes and/or pulmonary parenchyma, with or without an associated respiratory dysfunction [3].

The type, quantity, size and plasticity of the inhaled particles as well as the duration of the exposure and individual resistance determine the type of symptomatology, as well as the development and progression of the disease.

The term *malignant pneumoconiosis* is applied to a progressive fibrosis of the lung, which leads to very complicated functional limitations. Some examples are silicosis, asbestosis, anthracosilicotic and other mineral fibers.

Silica dust produces fibrous alterations in the lungs, decreasing the respiratory capacity and losing lung elasticity [4]. The pulmonary alveoli harden when replaced by fibrotic callosities, and the patient becomes more vulnerable to tuberculosis.

Silicosis is an irreversible disease: whoever contracts it has no chance of healing based on current medical evidence. In the initial stages there may be no symptom, i.e. the patient may be asymptomatic, but in the more advanced form the person tires easily with any effort due to breathing difficulties. There may also be no pain or other specific manifestations particularly during the early stages. It is diagnosed through radiodiagnosis [5].

The early detection of silicosis since its inception as a public health problem has been widely addressed by the International Labor Organization (ILO) and the World Health Organization (WHO). They have proposed a program to work cooperatively in a global fight against silicosis. This program has been based on the evaluation and classification of conventional chest radiographs to help diagnose this form of pneumoconiosis. The objective of this classification has been to codify the radiographic anomalies in a simple and reproducible way. This scheme has led to a better international comparability of statistics on this lung disease, which has led in the last decade to the use of other imaging techniques to evaluate lung tissue, including high-resolution computerized axial tomography (CAT) of the chest in 2008 and digital chest radiography in 2011[6].

The diagnostic basis of silicosis is the radiological finding of diffuse pulmonary opacities, associated with a history of silica dust inhalation. The occupational history of patients is one of the key elements for clinical orientation when faced with the finding of diffuse pulmonary nodules.

Given the frequent interobserver variability in the interpretation of a conventional and digital radiological plate, the ILO, in conjunction with international organizations concerned with worker's health, has developed a widely disseminated radiological classification, based on the type, size and profusion of the lung injury caused by silica inhalation.

At present, the use of other diagnostic imaging techniques, such as high-resolution CAT, has allowed early detection of parenchymal alterations caused by exposure to silica. However, the techniques do not have systematic information that allows them to be used as a standard method of evaluation for the early detection of silicosis, since their interpretation is still technician dependent [7].

3. What is Silica?

Silica is also known chemically as Silicon Dioxide (SiO_2) and is found in nature in various diverse forms of quartz, as a crystalline deposit. It is one of the most abundant elements in the earth's crust. It is present in almost all mineral deposits (copper, iron, coal, etc.) and in many industries (such as foundries, ceramics, glass factories, refractory bricks, abrasive blasting, etc.).

The main silicosis-producing agent is *free crystalline silica*, which appears in greater or lesser amounts in mines and rocks. Its concentration is greater in drilling works, mineral loading, grinding and crushing since these processes generate a large amount of dust, in which this malignant compound is found [8].

The higher the percentage of free silica the higher the risk of contracting silicosis. If minerals containing quartz are extracted, there will be abundant silica dust and, if protection measures are not adopted, it is likely that the worker will soon be exposed to potentially large volumes of silica dust which can lead to silicosis. However, when the work is carried out in a limestone mineral, or carbon or sulfur that does not contain as much quartz, the danger of contracting this disease is reduced , but as to extract these minerals it is essential to break the surrounding rock, which contains silica, there is also risk of contracting the disease. Silica is frequent in greater or lesser amounts and even normal sand, which may seem innocuous, contains this dangerous element.

Silicosis is contracted by the silica dust that enters the lungs when the worker breathes – the more dust in the environment and the longer the stay, the more silica dust can enter the lungs. In other words, if the worker breathes a significant quantity of crystallized free silica over a period of time, they can contract the disease in a shorter period [9].

For example, if a person works in a mechanical crusher without using any respiratory protection, it is almost undoubtedly, will experience some form of respiratory ill health. Often workers perception of the hazard is limited since it is the very fine particles which are virtually invisible are the most likely to result in being deposited deep into the lungs resulting ill health [10].

As obvious as it may sound, in order to sustain life, humans need to bring air to their lungs for gaseous exchange to occur. The purer the air, the less they will be exposed to the chance of contracting Silicosis or other respiratory diseases.

In industrial and mining operations, the air is never pure and often laden with airborne contaminants with only some being visible. In the case of the worker being unaware of the presence the however their bronchi and the whole internal respiratory system can often perceive the hazard.

Differing sized particles are usually inhaled together which larger particles being captured and expelled by the body's natural defenses through cough, sneeze and mucus mechanisms. Smaller particles however can remain in the lung and accumulate without causing immediate discomfort. Unbeknown to the workers this can be the starting stages of the process that will ultimately lead to silicosis. These microscopic particles over time can result in irremediable damage. The pouches that pump oxygen from the air (the alveoli) suffocating our organism (choking, coughing), causing discomfort when the disease is already serious, presenting nonspecific symptoms which have no correlation with the radiological findings and tests that measure pulmonary flows and volumes [11].

From the moment the worker start inhaling crystalline silica dust, the danger of contracting silicosis begins, which translates to a gradual destruction of the lung.Miners who work in a pit or sinkhole for 8 hours a day cannot defend themselves from the pollution of the dust they inhale, unless using the appropriate engineering controls and respiratory protective equipment.

4. Consequences of Silicosis

Many workers remain either unaware or indifferent to the nature of the hazard of silica dust and the consequence of contracting Silicosis. There is no natural immunity to contracting Silicosis although some persons appear to be more prone than others especially where preventative measures are not effective in limiting exposure.

Besides the physical harm inflicted to the worker, the consequences can be far reaching to include the co-workers, family, community and the country [12,15].

In most cases workers once sick is unable to continue with work or are forced to perform other jobs where the potential for exposure is eliminated or vastly reduced.

5. Prevention of Silicosis

The application of adequate dust control measures at the work environments is essential in disease prevention.

There are several effective ways to prevent the disease through the use of simple technology including:

1. Never drill without manual or mechanized water application either underground or on the surface
2. Do not allow the ore to fall from a great height, keeping the pits full, avoiding the excessive generation of dust
3. Plan blasting operations in order to minimize the number of personnel potentially exposure to dusts
4. Always water the site after the detonations, by using water in the form of a fine mist
5. In all the extraction processes of loading, transport, transfer, crushing, etc. proper engineering methods to be adopted to control the generation of dust.

6. Ventilation

It is possible to capture dust at the point of generation by means of enclosure and suctioning it with an extractor through ducts towards suitable bag filters.

In other cases, the dust is taken to cyclones, for its capture. It must be ensured that the dust does not concentrate in the general environment preventing the air from lifting it, by powerful currents such as jets of compressed air.

Ventilation is essential in any industrial activity not only as a means of protecting the health of workers, but also helps to improve production and avoiding uncomfortable working conditions. The better the ventilation conditions, the more progress can be made in the development of the works [13,16].

For the good functioning of these ventilation equipment, it is important that there is an adequate planned and preventative maintenance process. Suitable engineering methods will ensure a successful control of the generation of dust and ultimately avoid exposure to workers.

7. Water Treatment

In addition to ventilation, water must be used in all operations. Dry drilling must not be permitted. If this is not applicable, as in the case of special probes, dust collection systems or sleeves can be used to extract dust from the work environment to the outside if permitted.

To be effective water should be delivered in the form of a mist, by means of special nozzles that moisten the mineral without causing saturation due to excess water, and that allow the permanent draining of the mineral [14,17].

Galleries should also be kept humid, especially where blasting or detonations will be made, since a large amount of dust is produced. If possible dampen mineral each time it passes through a crusher which can also produces a large amount of dust.

8. Respiratory Protection

Despite of all the above measures, workers may still rely on suitable respiratory protection, which must be used continuously in order to ensure they are protected at all time. When the respirator is used correctly it prevents dust from entering the lungs, this because of the special filters that will hinder the passage of harmful particles.

A handkerchief or a damp cloth are no proper replacements for the respirator as is holding one's breath. These elements are little more than false reassurance, giving a false sense of security. The respirable dust is so fine that it passes through the meshes of the fabric. The respirator is then as necessary as a helmet and safety shoes. Before issuing any respiratory protection, the employer must ensure the proposed users have a thorough face fit test.

The precautions with the respirator are the following:

1. Keep it in good conditions, to ensure its correct functioning
2. Check that it fits perfectly on the face and does not let dirty air through the seals
3. Ensure that the valves effectively
4. Check type of respirator is suited for the task.
5. Change the filter when it is clogged, and make sure when doing so that it is well placed, without any wrinkles that allow the passage of dirty air
6. Perform positive and negative pressure tests every time the respirator is used.
7. Ensure users know the limitations of any protective equipment and how to use, store, maintain and how to replace components such as filters/cartridges through appropriate training and supervision.

9. Challenges

Among the challenges in the way we must address this public health problem – this includes: sensitization of workers to the magnitude of the health problem caused by silicosis and as a consequence, encourage the creation of regulatory bodies that are concerned with maintaining safe work conditions inside organizations.

Additionally, changes in national policies, encourage universities in the creation of specialization programs in occupational medicine and occupational health and hygiene and thereby disseminate to both employers and workers, designing preventive measures to preserve health and life. This includes promoting the global training of

physicians in the early identification of pulmonary changes produced by exposure to silica.

Acknowledgements

To my wife Irma for her understanding and love by allowing me the space and time to write and contribute to the knowledge of occupational medicine and to my peers for their support in contributing towards this article.

References

[1] Leung CC, Yu IT, Chen W. Silicosis. The Lancet. 2012; 379 (9830); 2008-18.

[2] Chan JYW, et al. RNA-Seq revealed ATF3-regulated inflammation induced by silica. Toxicology. 2018; 393: 34-41.

[3] Skuland T, Ovrevik J, Lag M, Refsnes M. Role of size and surface area for pro-inflammatory responses to silica nanoparticles in epithelial lung cells: importance of exposure conditions. Toxicol In Vitro. 2014; 28(2):146-55.

[4] Li X, et al. Bone marrow mesenchymal stem cells attenuate silica-induced pulmonary fibrosis via paracrine mechanisms. Toxicology Letters. 2017; 270: 96-107.

[5] Delgado García, Diemen. Silicosis: Controversy in detection. Med Segur Trab. 2014; 60(234): 4-8.

[6] Occupational Safety and Health. Guidelines for the use of the ILO International Classification of Radiographs of Pneumoconiosis. 2011 ed. rev. Geneva: International Labour Organization; 2011.

[7] Masoud Zare Naghadehi, Farhang Sereshki, F. Mohammadi. Pathological study of the prevalence of silicosis among coal miners in Iran: A case history. Atmospheric Environment. 2014; 83: 1-5.

[8] Sultan, Nayab. The Silent Killer. Solids and Bulk Handling. 2017; 3: 17-8.

[9] Garcia, D.D., Sultan, N. M., Yerba, O.R., Castro, S.J., Palacios, E.A., Cano, A.D. Silicosis and Smoking: Intrinsic Phenomenon in the Respiratory System. Advances in Applied Sociology. 2018; 8:659-667.

[10] LI Juan, et al. Crystalline Silica Promotes Rat Fibrocyte Differentiation in Vitro, and Fibrocytes Participate in Silicosis in Vivo. Biomedical and Environmental Sciences. 2017; 30(9): 649-60.

[11] Rimal B, Greenberg AK, Rom WN. Basic pathogenetic mechanisms in silicosis: current understanding. Current Opinion in Pulmonary Medicine. 2005; 11(2): 169-73.

[12] Delgado D, Aguilera M de los A, Delgado F, Rug A. The Experience of Miners Relocated to Alternative Positions due to Silicosis in the Andean of CODELCO, Chile, 2010. Safety and Health at Work. 2012; 3(2): 140-5.

[13] SULTAN, Nayab. The Silica Dust Hazard – What is it and why should I be concerned? Canadian Design and Construction Report. 2017 8(1): 12-7.

[14] Yuan J, et al. Polymorphisms in autophagy related genes and the coal workers ´ pneumoconiosis in a Chinese population. 2017; 632: 36-42.

[15] Abdelaziz R, Elkashef W, Said E. Tadalafil reduces airway hyperactivity and protects against lung and respiratory airways dysfunction in a rat model of silicosis. International Immunopharmacology. 2017; 40: 530-41.

[16] Deng H, et al. Protective effect of Ac-SDKP on alveolar epithelial cells through inhibition of EMT via TGF-β1/ROCK1 pathway in silicosis in rat. Toxicology and Applied Pharmacology. 2016; 294: 1-10.

[17] Gardiner C, Mills K. The cells that mediate innate immune memory and their functional significance in inflammatory and infectious diseases. Semin Immunol. 2016; 28: 343-50.