Original Article

Clinico-Radiological Profile of Silicosis Patients Presenting at a Tertiary Care Centre of Haryana, India

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Abstract

Objectives: The aim of this study was to study the patients working in stone crushing units presenting with respiratory symptoms for occupational lung disease, silicosis. **Patients and Methods:** Over a span of 2 years, 176 consecutive new stone crusher workers diagnosed with silicosis were clinically evaluated, including radiological investigations, spirometry, and sputum for acid-fast bacilli. **Results:** All patients were male manual workers with average age and duration of stone dust exposure of 42.9 years and 20.11 years, respectively; 57 (32.3%) gave a history of smoking; 33% of patients had taken anti-tubercular treatment in the past. However, sputum of none of the patients was found positive for acid-fast bacilli. Only 4 (2.2%) patients mentioned the use of gloves and masks during work shifts. Breathlessness was the most common symptom (92%), followed by cough (61.9%), chest pain (48.3%), expectoration (6.8%), hemoptysis (5.7%), and wheezing (2.8%). Chest radiograms showed opacities-small (up to 10 mm, 57.95%) and large (>10 mm, 17.04%); pleural thickening (97.2%), diaphragmatic thickening (97.2%), and calcifications (71%) etc., Predominant lesions on high-resolution computerized tomography scan of the thorax were mediastinal lymphadenopathy (94.3%), round opacities (90.3%) followed by parenchymal bands (59.1%) and linear opacities (52.8%). On spirometry, 71 (40.3%) patients had findings within the normal limits. **Conclusion:** It is reiterated that silicosis has severe debilitating effects on the health of subjects, and the situation warrants continuous monitoring.

Keywords: Occupational lung disease, rehabilitation, stone crusher, smoking

Introduction

Silica is the most abundant material in the earth's crusts and can be found in quartz, granite, sandstone, slate, and sand. Silica exists in both crystalline and amorphous (noncrystalline) forms, the latter having a relatively lesser toxicity profile and less common form of exposure. The stone contains approximately 100% free silica and the stone crushing, grinding, sieving, screening, mixing, storing, and bagging process liberates a huge amount of respirable crystalline silica dust in the working environment. Occupations with high silica exposure are mining, tunneling, road construction, pottery making, sandblasting, rock drilling, stone cutting, and quarrying. Silicosis, a progressive, irreversible, and incurable fibrotic pulmonary disease caused by the inhalation of respirable crystalline silica dust is the most common occupational lung disease globally.[1-3]

Crystalline silica can result in respiratory and nonrespiratory health effects. Exposure to a large amount of free silica can pass unseen because silica is nonirritant, odorless and does not lead to any immediate evident effect and therefore confused with ordinary dust. The inhaled (<5 µm) silica particles are removed from the lung parenchyma at a very slow rate. Thus, chronic silicosis can develop or progress even after occupational exposure has ceased. Since silicosis is a preventable but incurable disease, only supportive care is available along with lung transplantation for terminal cases.[4,5]

In India, according to estimates (1999), there were >3 million workers exposed to dust containing silica and another 8.5 million workers in construction and building activities who

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are similarly exposed to quartz.[6,7] In our country, silicosis is prevalent in the states of Gujarat, Rajasthan, Haryana, Uttar Pradesh, Bihar, Chhattisgarh, Jharkhand, Odisha, West Bengal, and Puducherry. The prevalence of silicosis in India ranges from 3.5% in ordnance factories to 54.6% in slate-pencil industries.[8]

State of Haryana (India) has stone crushing units in many districts, while workers in Faridabad (a district in Haryana) visit our tertiary care center for their health needs. A large number of silicosis cases were being observed in our hospital and also there are limited studies in our region; hence, the study of this nature was conducted.

Patients and Methods

A cross-sectional descriptive study was conducted at Employee State Insurance Corporation (ESIC) Medical College and Hospital, Faridabad, Haryana, India and consecutive new patients who reported to outpatient department of respiratory medicine during 2 years were evaluated to document clinical history, sociodemography, history of stone dust exposure, use of mask and gloves, smoking status, clinical evaluation, sputum examination for AFB by Zeihl-Neelsen staining method, cartridge-based nucleic acid amplification test (CBNAAT) for presumptive tuberculosis patients, spirometry, radiological investigation followed by clinical management.

All patients aged >18 years of age with a history of working in stone crusher units and who gave informed consent were included in the study after obtaining ethical clearance from the institute. The patients were informed about the confidential and voluntary nature of participation in the study without any fear or prejudice. However, none of the patients refused to participate in this study. All patients were offered symptomatic treatment, preventive (cough etiquette, tuberculosis, use of personal protective equipment, nutritional, prognostic) counseling, and anti-tobacco advice.

Spirometry was performed as per standard protocol following the American Thoracic Society/ERS guidelines.[9] Proper trials were given to ensure that subjects understood and become confident about the whole procedure. The reading was taken in a comfortable upright sitting position in front of the apparatus. Three readings were taken, and best of these was taken for the calculation. A spirometry record with FEV_1/VC value below its predicted lower limit of normal (LLN) for patients age, height, and sex was interpreted as having an obstructive abnormality. A restrictive defect was suspected if the vital capacity was reduced below the LLN; in the presence of normal or increased FEV_1/VC ratio (i.e., value above corresponding LLN).[10]

Smoking status was assessed using the smoking index (SI - product of the number of bidis/cigarettes smoked per day with the number of years smoked). Based on the SI, patients were categorized as never-smokers, light (SI: <100), moderate (SI: 101–300), or heavy (>300) smokers.

The findings of chest X-ray and high resolution computed tomography (HRCT) were noted as per the National Institute for Occupational Safety and Health of the Centers for Disease Control and Prevention (CDC/NIOSH 2.8(e), Revised January 2015) and International Labor Organization (ILO-2011) classification of radiograph of pneumoconiosis for epidemiological investigation.[11,12] Accordingly, on chest X-ray, opacities were divided based on the size as small (up to 10 mm) or large (>10 mm). Further, small opacities could be round or irregular. Based on size, small opacities were further subdivided into (*p* [size: up to 1.5 mm]; *q* [size: 1.5–3 mm]; *r* [size: 3 mm to 10 mm]). Based on shape, these small opacities were labeled as round (*p, q, r)* or irregular *(s, t, u)*. Large opacities were labeled as *A*-type (size between 10 to 50 mm); *B*-type (size >50 mm and up to right upper zone) and *C*-type (size of opacity more than right upper zone).

The radiological observations of all patients were reported based on mutual consensus among respiratory physicians, and in-case of discrepancy, an opinion was sought from a radiologist. The total study population consisted of 200 patients. However, radiological records of 24 patients were not available; hence, a total of 176 patients were finally considered. Data management was carried out to determine descriptive and bivariate statistics.

Results

Sociodemographic details

A total of 176 patients were evaluated, and all patients were male manual laborers working in stone crusher units aged between 20 and 70 years (mean age: 42.90 years). Maximum (42.6%) patients were of age group 41–50 years. The majority of them were working as daily-wage workers. Duration of stone dust exposure ranged from 1 to 40 years (mean duration: 20.11 years); however, nearly half (50%) of patients had 11–20 years of exposure. Only 04 (2.2%) of the patients mentioned the use of gloves and masks provided by the employer during stone crushing activities; however, 50% also reported covering their face with any available cloth. Nearly 57 (32.3%) patients gave a history of smoking. SI was calculated for all patients: 32 (18.2%) were mild smokers (SI <100), 18 (10.2%) moderate (SI: 101-300), and 7 (4%) had heavy (>301) SI. About one-third of patients had taken anti-tubercular treatment in the past. None of our study samples was found to be positive for acid-fast bacilli or CBNAAT. The majority (95%) did not use any of the personal protective equipment (mask, gloves) while at work. Sociodemographic details are shown in Table 1.

Symptoms

Breathlessness was the most common symptom reported by 162 (92%) patients, followed by cough (61.9%), chest pain (48.3%), expectoration (6.8%), hemoptysis (5.7%). Wheezing was the least reported symptom (2.8%). The majority of the patients had more than one symptom. The duration of these symptoms ranged from 1 to 20 years; 88.7% had symptomatology of less than 5 years; mean duration of illness was 2.75 years.

Table 1: Sociodemographic profile of silicosis patients

Variable	*n* (%)
Age (years)	
20-30	17 (9.7)
31-40	49 (27.8)
41-50	75 (42.6)
51-60	35 (19.8)
Duration of stone dust exposure (years)	
1-10	17 (9.7)
11-20	88 (50.0)
21-30	71 (40.3)
Symptoms	
Breathlessness	162 (92.0)
Cough	109 (61.9)
Chest pain	85 (48.3)
Expectoration	12 (6.8)
Hemoptysis	10 (5.7)
Wheezing	5 (2.8)
Duration of symptoms (years)	
<1	73 (41.5)
1-5	83 (47.2)
>5	20 (11.3)
History of anti-tubercular treatment	
Nil	118 (67.0)
At least once	58 (32.9)
Smoking index	
Mild (<100)	32 (18.2)
Moderate (101-300)	18 (10.2)
Heavy (>300)	7 (04.0)
Nonsmoker	119 (67.6)

Radiological observations

Chest radiograms (posteroanterior view) were graded as per the technical quality guidelines: 41 patients (23.3%) had X-ray technical quality 1, whereas technical quality 2 and 3 were found in 52 (29.5%) and 83 (47.2%) patients, respectively. On chest-X ray small opacities [size up to 10 mm; round or irregular]) were seen in 102 (57.9%) patients. The grading of small opacities were as follows: *p-type* (23.29%), *q-type* (14.20%), *r-type* (4.54%), *s-type* (5.11%), *t-type* (7.38%), *u-type* (9.09%); 64 chest x-rays did not have any smaller opacities. Large opacities were noted in 30 radiographs such as *A*-type in 18, while *B* and *C*-type opacity were seen in 6 radiographs. Large opacities were absent in 146 X-rays.

Zone wise distribution of opacities was noted for both right and left lung fields separately. The pattern of distribution was observed for upper (U), middle (M), lower (L) zones separately and in combinations (UM, ML, UL, UML). In the majority of radiographs, the opacities were present in all the three zones, UML of both right (57.9%) and left (59.6%) lung fields followed by UM (right 10.7%, left 9.6%); 16.4% and 18.1% of right and left lung fields did not have any opacities, respectively. Diffuse pleural thickening was present in almost all patients (97.2%), whereas localized pleural thickening was present in 75.6% of the patients. Many patients had both features. Other noted features were diaphragmatic thickening (171, 97.1%), costo-phrenic angle blunting (162, 92.0%), and calcifications (125, 71.0%).

Correlation was observed between the duration of stone dust exposure and opacities in chest X-rays, and it was noted that there was an overall increase in the number of opacities with the increasing duration of exposure. This increase was statistically significant for smaller opacities ($P = 0.042$) but not for larger ones ($P = 0.260$) [not shown in table].

High resolution computed tomography

On HRCT thorax, predominant lesions seen were mediastinal lymphadenopathy (94.3%), round opacities (90.3%) followed by parenchymal bands (59.1%), and linear opacities (52.8%). Other important findings were pleural thickening (25%), ground-glass opacities (24.4%), large opacities (20.5%), confluence of opacities (16.5%), emphysema (13.1%), bronchiectasis (11.9%), cavities (10.8%), tree-in-bud opacities (10.8%), bronchial wall thickening (6.3%), egg-shell calcification (3.4%), sub-pleural atelectasis (3.4%), round atelectasis (2.8%), pleural effusion (2.8%), dependent opacities (2.3%), and mosaic pattern (2.3%). Honeycomb appearance and bullae were seen in only two patients each. None of the patients demonstrated features of malignancy. Details are shown in Table 2.

Smaller opacities were seen in 102 (57.9%) radiographs, whereas 159 (90.3%) computed tomography (CT) scans had this finding. Large opacities and the confluence of opacities were visible in 65 (36.9%) CT scans but only in 30 (17.04%) radiographs, thereby showing limitation of radiograph as a 2-dimensional depiction.

Spirometry

71 (40.3%) patients had spirometric findings within the normal limits whereas 105 (59.65%) had findings outside normal limits that were suggestive of the restrictive, obstructive, or mixed pattern. These were as follows: 67 (38.1%) patients had the restrictive pattern, 24 (13.6%) mixed, and only 14 (8%) had the pure obstructive pattern. Details are shown in Table 3.

Discussion

Our hospital-based descriptive study covering 176 silicosis patients revealed all were male manual laborers with the average age of 42.9 years and mean duration of stone dust exposure of 20.11 years. The majority (95%) did not use any of the personal protective equipment (mask, gloves) while at work. Breathlessness was the most common symptom reported by 162 (92%) patients followed by cough (61.9%), chest pain (48.3%), etc., with an average duration of illness of 2.7 years. Chest radiograms showed small opacities (up to 10 mm) in 57.95% of patients and large (>10 mm) opacities in 17.04% of patients. In the majority of radiographs, the opacities were present in all the three zones, UML of both right (57.9%) and left (59.6%) lung fields. On HRCT thorax, predominant lesions were mediastinal

Table 2: High resolution computed tomography thorax findings of silicosis patients (*n*=176)

Feature	Patients (%)
Round opacities	159 (90.3)
Linear opacities	93 (52.8)
Honey combing	2 (1.1)
Ground glass opacities	43 (24.4)
Emphysema	23 (13.1)
Large opacities	36 (20.5)
Pleural thickening	44 (25.0)
Pleural calcifications	4 (2.3)
Confluence of opacities	29 (16.5)
Bronchiectasis	21 (11.9)
Bronchial wall thickening	11 (6.3)
Bullae	2 (1.1)
Calcified granuloma	4 (2.3)
Cavity	19 (10.8)
Dependent opacities	4 (2.3)
Pleural effusion	5 (2.8)
Egg shell calcification	6 (3.4)
Mediastinal lymphadenopathy	166 (94.3)
Mosaic pattern	4 (2.3)
Parenchymal band	104 (59.1)
Round atelectasis	5 (2.8)
Sub pleural atelectasis	6 (3.4)
Tree in bud opacities	19 (10.8)
Other features	24 (13.6)

Table 3: Spirometry findings of silicosis patients (*n*=176)

PFT	Patients (%)	Mean ratio	Mean FVC	Mean FEV1
Normal	71 (40.3)	82.67	3.34	2.74
Restrictive	67 (38.1)	83.94	2.42	2.03
Mixed	24 (13.6)	59.51	2.39	1.36
Obstructive	14 (08.0)	64.31	3.21	2.13

PFT: Pulmonary function test, FVC: Forced vital capacity, FEV1: Forced expiratory volume in 1 s

lymphadenopathy (94.3%), round opacities (90.3%) followed by parenchymal bands (59.1%), and linear opacities (52.8%), etc.

Clinical spectrum of this disease can range from asymptomatic condition to patients presenting with acute silicosis, chronic obstructive pulmonary disease, bronchitis, emphysema, lung cancer, kidney damage, scleroderma, etc., requiring hospital admission.[13-17] Unless there is high suspicion, diagnosis may be missed by clinicians working in limited resource settings. We were able to evaluate such a large number of patients at our center since our hospital caters to occupational diseases. The present study findings reflect the largest database of silicosis patients from India, and based on our current experiences, it is proposed to develop a silicosis disease registry in future. A few of the limitations include the amount of actual dust exposure among workers may vary; there were no female patients; the possibility of human error in radiological observations plus the study covered only those patients who reported to our hospital out-patient department and therefore study findings lacks generalizability.

A review of the literature demonstrated a preponderance of males being affected more than females, probably due to the frequency of exposure and heavy physical demands of the stone crushing industry. However, authors have observed women, including spouses also working in the same occupational sector. Majority of patients (70.45%) belonged to economically and demographically young age of 20–50 years with wider social ramifications. Majority (90.34%) of patients had stone dust exposure of >10 years, and breathlessness (92%) was the most common symptom followed by cough (61.9%), chest pain (48.3%), etc., Similar findings were reported in other research studies as well.[18-23]

In our study, it was observed that 71 (40.35%) patients had normal PFT, probably due to early-stage disease and younger age. However, 105 (59.65%) patients had PFT findings outside normal limits. The severity of spirometric findings was in contrast from community-based studies carried amongst stone quarry workers where-in abnormal PFT was found in 43.4% (Maharashtra) and 40.4% (West Bengal) persons.[24,25] In our analysis, it was noticed that the pulmonary function test declines as the duration of stone dust exposure increases. Like most studies, we have included smokers in our study population, but Lopes *et al*.[26] have excluded smokers from their study as both smoking and silica are known to cause deterioration of lung volumes, decrease macrophage activity, and causes emphysema. We found that 57 (32.38%) of our subjects had a history of smoking.

Radiological imaging plays a critical role in the diagnosis of silicosis. Bhawna *et al*. have described similar findings among pneumoconiosis patients.[27] Sivanmani and Rajathinakar in their study carried out in Coimbatore (Tamil Nadu) reported radiological nodular opacities with upper-zone predominance in the majority of cases.[28] Hughes *et al*.,[29] in their study, showed an increasing trend of x-ray opacities with an increase in the duration of cumulative silica exposure and age of the workers. We did a similar correlation analysis between the years of silica dust exposure and opacities in chest x-rays. It was observed that there is an overall increase in the number of opacities with the increasing duration of exposure, but this increase was statistically significant for smaller opacities ($P = 0.042$) only and not for the larger ones ($P = 0.260$).

Silicosis, as an occupational disease, is mentioned in the ancient text but in the modern era was diagnosed for the first time in India among workers in Kolar goldfield in Mysore, Karnataka, during 1934. In India, there are constitutional provisions (legislation, act, schemes, rules) covering health, safety, working hours, conditions at work and employment, payment of wages, compensation, disability, death, and maternity-related issues.[30] Some of these are covered under Factories Act (1948), Employees State Insurance (ESI) Act (1948), Mines Act (1952), etc., The Ministry of Labour and Employment, Government of India, approved the national policy on safety, health, and environment at workplaces in 2009.

Occupational health has been one of the components of the National Health Policy in 1983, 2002, 2017, and the Government of India under the Ministry of Health and Family Welfare launched a program entitled "National Program for Control and Treatment of Occupational Diseases" in 1998–1999. The National Institute of Occupational Health, Ahmedabad, established in the year 1970 and has been earmarked as the nodal agency for the same. Lately, many state governments have started rolling out financial compensation for silicosis affected patients (personal communication).

Conclusion

Our study provides a snapshot of clinical, radiological, and spirometric findings in patients from stone crushing units. This study provides an insight that warrants more societal attention even though poverty, social backwardness, malnutrition, risk exposure, alcohol intake, tuberculosis, limited awareness, poor health practices and treatment compliance, sporadic occupational health preventive measures, corruption, and poor resources is a stark reality in our society.[31-40] It is reiterated that silicosis is a major occupational health hazard leading to respiratory debility of varying nature, as evident from this original study conducted in Haryana, India, and the situation warrants continuous monitoring, including the use of appropriate personal protective equipment.

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Conflicts of interest

There are no conflicts of interest.

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