Six cases of silicosis: implications for health surveillance of stonemasons

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Background Silicosis is one of the oldest occupational lung diseases, but it continues to cause significant morbidity and mortality worldwide.

Aims To report cases of silicosis presenting to two specialist respiratory clinics.

Methods A retrospective analysis of prospectively collected data of cases of silicosis in workers referred to specialist respiratory clinics.

Results Over the course of 6 years, six cases were identified. The patients were all male with an age range between 24 and 39 years. The duration of silica exposure ranged between 7 and 20 years (mean 13 years). Four cases were entirely asymptomatic at presentation, and two cases described minimal shortness of breath on exertion. Pulmonary function tests were normal in three cases, and a mild restrictive ventilatory defect was documented in the other cases. All had a low apparent predicted probability of pneumoconiosis based on health questionnaires, spirometry and duration of silica exposure. The initial chest X-ray was abnormal in all six cases with radiological evidence of silicosis (International Labour Office profusion category ≥1/1) on imaging, and all had evidence of silicosis on high-resolution computed tomography (HRCT). Three patients had already progressed to progressive massive fibrosis on HRCT scanning at the time of referral to specialist respiratory services.

Conclusions The appearances of these six cases of silicosis in young, asymptomatic construction workers emphasizes the importance of enforcing effective exposure control and comprehensive surveillance programmes. Our observations highlight the importance of having a low threshold for early radiological screening to promote early and effective detection of this disease.

Key words Health surveillance; occupational health care delivery; occupational respiratory disease; pneumoconioses; silicosis.

Introduction

Silicosis is a pneumoconiosis caused by the inhalation of crystalline silica. Workplace activities such as cutting, grinding and polishing materials that contain respirable crystalline silica produce fine dusts and are associated with an increased risk of developing silicosis. The illness should be preventable by a combination of thorough occupational hygiene measures and the use of appropriate personal protective equipment [1]. However, the condition continues to be reported in many countries. In the UK, there were 16 deaths from silicosis in 2011, which is close to the annual average for the last 10 years. Forty new cases of silicosis were assessed for industrial injuries disablement benefit in 2011 and this figure is likely to be an underestimate of the incidence of the condition [2].

In parallel with workplace control measures, health surveillance of workers exposed to respirable crystalline silica remains important in order to identify individuals at the earliest stage of the disease. The optimum method of surveillance remains uncertain and a variety of approaches have been proposed. In the UK, the Health and Safety Executive (HSE) recommends health surveillance is considered for all employees in occupations with exposure to respirable crystalline silica. The occupations at greatest risk include mining, quarrying,
siltone works, foundries, potteries, brick and tile making and stone masonry. Construction work involving cutting or breaking stone, concrete or brick, abrasive blasting and tunnelling is also associated with the development of silicosis. The HSE recommends health surveillance is undertaken where there is a reasonable likelihood of silicosis developing and suggests that surveillance comprises enquiry into new or worsening respiratory symptoms with consideration of chest X-rays at intervals. If there is a risk of silicosis, baseline assessment and discussion regarding the need for a chest X-ray at the start of employment are also recommended [2]. Recently, Suarthana et al. [3] have proposed a model to estimate the probability of an individual worker having pneumoconiosis from questionnaire and spirometry results with the potential to reduce the requirement for chest X-rays.

We present our experience with six cases of silicosis in young construction workers referred to two specialist respiratory clinics in Edinburgh, Scotland from 2007 to 2013. Five different employers were involved in the six cases, which illustrate that the issue of health surveillance remains very relevant.

Case 1

A 24-year-old male had worked as a stonemason for 7 years, with around 6.5 years cutting and dressing stone. Dressing stone involves using tools such as hammers, chisels, pitchers and angle grinders to trim stone. He had worked for a small company from the age of 17. There was no formal comprehensive health surveillance programme, but he did report undergoing lung function testing periodically. He had never undergone chest X-ray screening. He was provided with a face-fitted dust mask and overalls. Stone dust was extracted through a water-wall system. Six months prior to presentation, he moved to a new small company with which he undertook general building work and stonemasonry. He continued to cut stone with a 9 inch angle grinder and used a dust mask. He was referred to a specialist clinic as routine lung function tests were felt to lie outside the desirable range. He reported nasal stuffiness but did not report cough, sputum production, shortness of breath or chest pain. He had never smoked tobacco and had no other significant illness. There were no abnormal examination findings. Pulmonary function testing revealed normal lung function as described in Table 1. Gas transfer was also normal. His lymphocyte count was reduced at presentation at $1.36 \times 10^9/l$ (normal value $1.5–4.0 \times 10^9/l$). A chest X-ray showed increased nodularity throughout. A high-resolution computed tomography (HRCT) scan demonstrated multiple small punctuate, high-density, well-defined nodules with a random distribution throughout all lobes, and relative sparing of the lower lobes consistent with silicosis. A lung biopsy was not performed.

Case 2

A 38-year-old male had worked as a stonemason for 14 years. He began working with a small firm at the age of 21. He spent his first year at college and then 3 years as a factory apprentice dressing stone. During this period, he used airguns to chisel stone, releasing large quantities of stone dust. Respiratory protective equipment (RPE) took the form of a paper mask. At the age of 25, he left the company to work on a building site for 2 years, during which time he very infrequently cut stone. At the age of 27, he returned to his previous stonemasonry employment. He reported conditions were worse on his return with the routine use of angle grinders and machines with diamond tip edges to polish stone. Both tools released large quantities of dust. Dust extraction systems were available, but variably employed.

<table>
<thead>
<tr>
<th>Case number</th>
<th>Patient age (years)</th>
<th>Years of exposure to silica</th>
<th>Pulmonary function at presentation*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>24</td>
<td>7</td>
<td>FEV1 % (% predicted)</td>
</tr>
<tr>
<td>2</td>
<td>38</td>
<td>14</td>
<td>2.8 (72)</td>
</tr>
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<td>3</td>
<td>37</td>
<td>20</td>
<td>3.53 (84)</td>
</tr>
<tr>
<td>4</td>
<td>29</td>
<td>12.5</td>
<td>3.1 (72)</td>
</tr>
<tr>
<td>5</td>
<td>36</td>
<td>17</td>
<td>2.34 (65)</td>
</tr>
<tr>
<td>6</td>
<td>39</td>
<td>7</td>
<td>4.05 (112)</td>
</tr>
</tbody>
</table>

The factory had no water-wall. After 10 years with the company, rubber half-face masks were purchased, but their use was not enforced. There was no formal health surveillance and he never underwent chest X-ray screening. After 14 years' work as a stonemason, he was made redundant. The redundancy package involved a medical, where he was told his chest X-ray was abnormal. At this time he did not experience cough or sputum production, but had become aware of breathlessness on climbing steep hills. He was an ex-smoker of 4 years with a 20 pack-year history. There were no abnormal examination findings. Pulmonary function tests revealed a mild ventilatory defect. Lung volumes were reduced, but gas transfer was preserved. Following use of a salbutamol nebulizer, there was a 300 ml increase in forced expiratory volume in 1 s (FEV1), consistent with asthma. His lymphocyte count was normal at 3.83 × 10⁹/l. His HRCT scan (Figure 1) shows silicosis and large conglomerate pulmonary masses consistent with progressive massive fibrosis.

**Case 3**

A 37-year-old male had worked as a stonemason for 20 years, beginning at the age of 17 working as an apprentice with a small company for 4 years. His work mostly involved dressing and chiselling stone, and he reported that conditions were poor. He was not supplied with RPE and reported there was no extraction equipment and no dampening. The yard was enclosed with one large saw in the centre, which released large quantities of dust. At 21, he moved to another small firm and again his work mostly involved dressing stone. Rubber half-face masks were available but not worn. After 10 years, the company tried to improve working conditions with the purchase of extractor fans and a water-wall, but he reported that it was very difficult to avoid dust despite these measures. He presented after routine surveillance detected a decline in lung function >3 years, although the absolute values remained within normal limits. He denied any shortness of breath, cough, sputum, or chest pain, had no past medical history of note and was a lifelong non-smoker. There were no abnormal examination findings. Pulmonary function tests were normal, as was gas transfer, but his lymphocyte count was reduced at 1.00 × 10⁹/l. His chest X-ray (Figure 2) and HRCT scan (Figure 3) showed silicosis and progressive massive fibrosis.

**Case 4**

A 29-year-old male had worked as a stonemason with the same small company from the age of 17 for 12.5 years. His work mostly involved cutting stone with a 9 inch angle grinder and chiselling stone with an air-gun. He was provided with a face-fitted dust mask and overalls. Stone dust was extracted through a water-wall system. He presented after a routine employment chest X-ray was reported as abnormal. He did not report any respiratory symptoms and examination findings were unremarkable. He had smoked 15 cigarettes per day since age 16 and had a history of well-controlled asthma. Pulmonary function tests revealed a mild restrictive defect as described in Table 1. Lung volumes and gas transfer were normal, but his lymphocyte count was reduced at 1.20 × 10⁹/l. A chest X-ray showed bilateral apical shadowing and increased nodularity. His HRCT scan is shown in Figure 4.

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**Figure 1.** HRCT of Case 2 showing well-defined centrilobular nodules in the upper lobes, enlarged hilar and mediastinal lymph nodes and large conglomerate pulmonary masses consistent with progressive massive fibrosis.

**Figure 2.** Chest X-ray showing numerous scattered small pulmonary nodules with contraction of the upper lobes in keeping with silicosis and established fibrosis.
Case 5
A 36-year-old male had worked as a stonemason with the same small company for 17 years. His work mostly involved cutting stone with 9 inch angle grinders or chisels, but he also used machinery to polish stone. He had worn a rubber mask when dressing stone. The company had used dust extraction systems and the factory had a water-wall. He presented with shortness of breath on exertion climbing steep hills and was found to be hypoxic by his general practitioner. He denied any cough, sputum, fever or weight loss. Past medical history included systemic scleroderma and Raynaud’s syndrome. He was a lifelong non-smoker. Examination revealed no abnormalities. Pulmonary function tests revealed a mild restrictive ventilatory defect and lung volumes were also reduced, although gas transfer was preserved. He was hypoxic with a partial pressure of oxygen of 9.3 kPa on air and his lymphocyte count was reduced to $1.11 \times 10^9/l$. His chest X-ray is shown in Figure 5. A HRCT scan showed multiple prominent calcified lymph nodes and multiple small pulmonary nodules between 1 and 3 mm in diameter throughout both lung fields, with pleural thickening above both apices, consistent with silicosis. In view of the known association between silica exposure and scleroderma [4], it is felt that they may be related in this case.

Case 6
A 39-year-old male had worked as a stonemason with a small company for 7 years between the ages of 18 and 25. His work involved chiselling stone with an airgun and cutting stone with hammers and a 9 inch angle grinder. The factory had no water-wall and the company did not enforce the use of dust extraction systems. Paper masks were available, but he did not wear one. Since the age of 25, he had worked as a plumber with no further exposure to stone dust. He presented to the accident and emergency department with pleuritic chest pain. His past medical history included a history of pulmonary
embolism, and he was lupus anticoagulant positive. He was an ex-smoker with a 20 pack-year history. His admission chest X-ray revealed no abnormalities. A CT pulmonary angiogram showed no evidence of pulmonary embolism, but identified multiple nodules in the mid to upper zones measuring between 2 and 5 mm in diameter. There were also small areas of nodular calcification and multiple enlarged hilar and mediastinal lymph nodes. The appearances were felt to be consistent with silicosis. His chest pain resolved spontaneously and no other respiratory symptoms were reported. There were no abnormal findings on examination, and pulmonary function tests and gas transfer and lymphocyte count \((2.16 \times 10^9/l)\) were all normal.

**Discussion**

In this paper, we report six cases of men aged <40 years presenting with silicosis. The continuing occurrence of such cases has important implications for workers, employers and occupational health professionals.

Guidance from the UK HSE is that where there is a reasonable likelihood of silicosis developing chest X-ray screening is recommended as part of the clinical investigation of workers who report new or worsening respiratory symptoms [5]. However, it is unlikely that any of these men would have been detected by questioning as three did not report any respiratory symptoms, one reported breathlessness on inclines but had asthma and one reported mild shortness of breath only. As with other forms of pneumoconiosis, for example, coal workers' pneumoconiosis, the earliest stages of the condition may be asymptomatic.

The World Health Organization (WHO) recommends all workers exposed to crystalline silica should undergo lifelong health surveillance. They advise that a baseline chest X-ray should be obtained at the start of employment, with a repeat chest X-ray performed after 2–3 years. A screening chest X-ray should then be performed every 2–5 years thereafter. Spirometry and symptom questionnaires should also be obtained annually from the start of employment and should prompt referral to specialist respiratory services if any abnormality is detected [6]. Based on our experience in two specialist respiratory clinics in Edinburgh, Scotland, it appears that these recommendations are not currently being followed universally by UK stonemasonry employers. Spirometric assessment of lung function was performed in two cases in our study, and in each case prompted referral. However, in Patient 1, lung function tests performed by a hospital laboratory were in fact within the normal range. In Patient 3, hospital lung function tests were also within normal range, but review of the tests performed during surveillance showed decline in ventilatory capacity >3 years of assessment, although the absolute values remained within normal limits, illustrating a potential pitfall in the interpretation of tests of ventilatory capacity in younger workers. Lung growth, as defined by measurement of the FEV\(_1\), may continue into the late teens and early 20s. Once the maximum FEV\(_1\) is achieved, it is usually maintained until the late 30s, following which gradual age-related decline begins [7]. Therefore, it may be difficult to decide, based on FEV\(_1\) measurement, whether lung function is unaffected or not. A decline in FEV\(_1\) in a worker exposed to silica in their 20s and early 30s should prompt further assessment. The WHO advises that spirometry should be considered abnormal if the FEV\(_1\) or forced vital capacity are below the lower boundary of the 95% confidence interval for the average value of an appropriate reference group. The loss of 15% from the baseline value should also be considered abnormal [6]. A reduction in the carbon monoxide diffusing capacity may reflect cotic damage at the level of alveolar-capillary unit [8]. However, it is unlikely that more detailed lung function testing would have aided earlier detection as gas transfer was normal in all six of our cases.

Despite UK HSE guidance, it is unclear what should prompt a chest X-ray and what intervals are appropriate. More specific guidance on when to perform chest X-rays has been provided by Suarthana et al. [3]. However, applying this model to our cases would have indicated the predicted probability of pneumoconiosis in all six cases to be 0% and they would not have been referred for a chest X-ray. However, all of these patients had radiological evidence of silicosis (International Labour Office [ILO] profusion category ≥1/1) on imaging and CT scanning confirmed the presence of progressive massive fibrosis in three cases.

When considering a chest X-ray, it must also be recognized that a normal chest radiograph (ILO 0/0) does not exclude the presence of silicosis. A recent study by Meijer et al. [9] confirmed the greater sensitivity of HRCT scanning in detecting small parenchymal changes, interstitial fibrosis and pleural abnormalities in workers with chest X-rays considered normal (ILO profusion category 0/0). These findings indicate that a substantially higher rate of low-grade silicosis may be expected in respirable crystalline silica dust-exposed workers than is being detected by traditional screening methods [9], suggesting the need to explore the potential of low-dose helical CT screening in people at high risk of silicosis.

These six cases of silicosis in young, asymptomatic workers demonstrate that surveillance programmes based on symptom reporting, spirometry and even chest X-rays may miss relatively advanced cases of silicosis in young men. Stringent enforcement and adherence to dust control measures remains the best method of preventing the development of silicosis, but further consideration of the
optimum means of health surveillance for those at risk is also required.

**Key points**

- Silicosis continues to cause significant morbidity and mortality, in developed as well as developing countries, and patients with an apparently low predicted probability of pneumoconiosis, based on symptom questionnaires, spirometry and duration of silica exposure, can nonetheless develop silicosis.
- Occupational health professionals dealing with at-risk occupational groups should have a low threshold for requesting radiological screening in addition to other health surveillance procedures.
- Stringent enforcement and adherence to dust control measures remain the best method of preventing the development of silicosis.

**Conflicts of interest**

None declared.

**References**


