# SHORT REPORT

## Determinants of spirometric abnormalities among silicotic patients in Hong Kong

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### Background
Silicosis is the second commonest notified occupational disease in Hong Kong. Most cases have worked in construction and/or quarry work [1]. Hand-dug caissons were extensively employed for foundation work in the 1970s and 1980s [1].

### Aim
To characterize the determinants of spirometric abnormalities in silicosis.

### Method
The spirometric patterns of consecutive silicotic patients on confirmation by the Pneumoconiosis Medical Board from 1991 to 2002 were correlated with demographic characteristics, occupational history, smoking history, tuberculosis (TB) history and radiographic features by univariate and multiple regression analyses.

### Results
Of 1576 silicotic patients included, 55.6% showed normal spirometry, 28.5% normal forced vital capacity (FVC ≥ 80% predicted) but reduced forced expiratory ratio (FER < 70%), 7.6% reduced FVC but normal FER, and 8.4% reduced both FVC and FER. Age, ever-smoking, cigarette pack-years, industry, job type, history of TB, size of lung nodules and progressive massive fibrosis (PMF) were all significantly associated with airflow limitation on univariate analysis (all \( P < 0.05 \)), while sex and profusion of nodules were not. Only age, cigarette pack-years, history of TB, size of lung nodules and PMF remained as significant independent predictors of airflow obstruction in multiple logistic regression analysis. After controlling for airflow obstruction, only shorter exposure duration, history of TB and profusion of nodules were significant independent predictors of reduced FVC. As well as age, history of TB, cigarette pack-years, PMF and nodule size contributed comparable effects to airflow obstruction in multiple linear regression analyses, while profusion of nodules was the strongest factor for reduced vital capacity.

### Conclusions
In an occupational compensation setting, disease indices and history of tuberculosis are independent predictors of both airflow obstruction and reduced vital capacity for silicotic patients.

### Key words
Silicosis; spirometry; smoking; tuberculosis.

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Criterion for the diagnosis of silicosis is the presence of round and/or irregular opacities in the lungs, with profusion > 1/0. All patients undergo simple spirometry under the supervision of a respiratory physician and a trained nurse. Spirometry is performed using a dry wedge-type bellow spirometer (Vitalograph PFT II plus, Buckingham, UK), with the results corrected for body temperature, pressure and water vapor saturation. For the spirometric tracings, acceptability is judged according to the criteria of the American Thoracic Society [3,4]. The best forced vital capacity (FVC) and forced expiratory volume in 1 s (FEV1) before the inhalation of bronchodilator within 6 months of the initial diagnosis were extracted, and compared with the predicted normal according to data previously published for Chinese in Hong Kong [5,6]. The aim of this study was to characterize the determinants of spirometric abnormalities among silicotic patients.
Methods

All patients with the diagnosis of silicosis confirmed by the Pneumoconiosis Medical Board from 1991 to 2002 inclusive were included. The assessment records of all patients were reviewed, and the relevant clinical information, radiographic findings and spirometric parameters were captured. The principal job type (job type involved for over 50% of exposure period) and total duration of dust exposure were employed as proxy measures of dust exposure because quantitative measurements of dust levels were not available. Forced expiratory ratio (FER = FEV1/FVC) < 70% was used as the criterion for airflow obstruction. A purely restrictive pattern was defined as having an FVC < 80% of the predicted and an FER ≥ 70%. The lung function patterns were correlated with background demographic characteristics, occupational history, smoking history, history of tuberculosis (TB) and radiographic features first by univariate analysis (two-sample t-test for continuous data, and χ²-test for categorical variables) and then by multiple logistic regression and multiple linear regression analyses. Multi-collinearity was considered and excluded before entering of variables into multiple regression analysis. A P value of < 0.05 was taken to be statistically significant.

Results

A total of 1576 consecutive silicotic patients were included, after exclusion of 61 cases without satisfactorily performed spirometry. They were all ethnically Chinese. Their background characteristics are shown in Table 1.

Table 1. Background and clinical characteristics of silicotic patients at diagnosis

<table>
<thead>
<tr>
<th>Variable</th>
<th>Overall (n = 1576)</th>
<th>FER &lt; 70 (n = 581)</th>
<th>FER ≥ 70 (n = 995)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male sex</td>
<td>98.8</td>
<td>98.6</td>
<td>98.9</td>
<td>0.634</td>
</tr>
<tr>
<td>Age, yr</td>
<td>56.4 ± 11.3</td>
<td>61.7 ± 10.5</td>
<td>53.3 ± 10.6</td>
<td>0.000</td>
</tr>
<tr>
<td>Ever-smoker</td>
<td>89.1</td>
<td>91.2</td>
<td>87.8</td>
<td>0.038</td>
</tr>
<tr>
<td>Cigarette pack-year</td>
<td>25.0 ± 22.3</td>
<td>30.7 ± 24.87</td>
<td>21.6 ± 20.0</td>
<td>0.000</td>
</tr>
<tr>
<td>Industry</td>
<td>Construction</td>
<td>67.6</td>
<td>60.6</td>
<td>0.000</td>
</tr>
<tr>
<td>Exposure, yr</td>
<td>23.6 ± 9.4</td>
<td>24.8 ± 10.3</td>
<td>22.9 ± 8.8</td>
<td>0.000</td>
</tr>
<tr>
<td>Size (mm)</td>
<td>1.5</td>
<td>30.7</td>
<td>24.4</td>
<td>0.000</td>
</tr>
<tr>
<td>PMF</td>
<td>22.4</td>
<td>30.3</td>
<td>17.8</td>
<td>0.000</td>
</tr>
<tr>
<td>FVC, L</td>
<td>3.0 ± 0.8</td>
<td>2.7 ± 0.8</td>
<td>3.2 ± 0.7</td>
<td>0.000</td>
</tr>
<tr>
<td>FEV1, L</td>
<td>95.8 ± 18.7</td>
<td>93.2 ± 21.6</td>
<td>97.3 ± 16.6</td>
<td>0.000</td>
</tr>
<tr>
<td>FEV1%</td>
<td>2.2 ± 1.0</td>
<td>1.6 ± 0.6</td>
<td>2.6 ± 1.0</td>
<td>0.000</td>
</tr>
<tr>
<td>FER</td>
<td>85.4 ± 24.0</td>
<td>68.9 ± 23.0</td>
<td>95.1 ± 18.6</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Figures presented are percentages unless stated otherwise.

a Underground drillers: 703 caisson workers, 10 miners, 7 tunnel workers.
b Surface drillers in construction trade or quarries.
c Stone crushing, and cutting in quarries.
d Jobs involving fine silica powder: 54 gem-, 25 ceramic-, 3 glass-related work.
e Other medium exposure jobs: 148 construction/demolition labourers, 24 cement/plasterers, 8 shot-firers, 7 brick/tile workers.
f Other lower exposure jobs: 22 mechanics, 19 supervisory/supportive jobs, 13 metal/welders, 6 drivers.
g Mean ± SD.
The mean duration of exposure was 23.6 ± 9.4 SD years. Underground drillers had a shorter exposure period than the rest (21.8 ± 7.6 versus 25.1 ± 10.5 years, \(P < 0.001\)). Overall, 55.6% showed normal baseline lung function, 28.5% showed normal FVC but FER < 70%, 7.6% showed reduced FVC but FER ≥ 70%, 8.4% showed both reduced FVC and FER. Significant inter-correlation was found among many of the variables. The three commonly employed disease indices of nodular profusion, nodular size and progressive massive fibrosis (PMF) were significantly correlated among themselves (Pearson \(r = 0.179–0.379\)) and with the spirometric parameters (Pearson \(r = 0.004\) to \(0.227\)).

On multiple logistic regression analysis using only background and exposure-related variables, age, shorter dust exposure duration, job type and history of TB were independent predictors of PMF at time of initial presentation (all \(P < 0.05\)). Similarly, age, cigarette pack-years and history of TB were independent predictors of airflow obstruction (FER < 70%) while shorter dust exposure duration and history of TB were independent predictors of reduced FVC (FVC < 80% predicted).

On full multiple logistic regression analysis with the addition of diseases indices, airflow obstruction was predicted only by age (odds ratio: 1.07 per year), cigarette pack-years (odds ratio: 1.01 per year), history of TB (odds ratio: 1.7), size of lung nodules (odds ratio: 1.0, 1.1, 1.8 for successive grades) and PMF (odds ratio: 1.7), while reduced FVC was predicted only by shorter exposure duration (odds ratio: 0.98 per year), history of TB (odds ratio: 1.7), profusion of nodules (odds ratio: 1.0, 1.9, 14.2 for successive grades) and airflow obstruction (odds ratio: 2.1).

Table 2 summarizes the effects of various independent predictors on FER and FVC (expressed as a percentage of predicted value) in multiple linear regression analysis.

### Discussion

In view of the healthy worker effect and selective presentation, due caution is required in the extrapolation of results from longitudinal studies in a compensation setting. In particular, heavily dust-laden jobs might be linked with shorter exposure duration, and the latter in turn, with reduced vital capacity and progressive massive fibrosis.

Disease indices such as profusion and size of nodules and presence of PMF were more important than exposure duration or other dust exposure-related proxies as independent predictors of both airflow obstruction and FVC among silicotic patients on presentation. For airflow obstruction, the combined impact of PMF and size of nodules (as reflected by the sum of the squares of their partial correlation in Table 2) was at the same order of that of smoking and TB. Nodule size and PMF, disease indices likely to be associated with distortion of architecture of surrounding lung tissue, were predictive of airflow obstruction. On the other hand, nodule profusion, an index of diffuse lung involvement, was predictive of reduced vital capacity. TB was associated with both airflow obstruction and reduced vital capacity.

Overall, disease indices only account for a modest proportion of the total variation of these lung function parameters. The degree of correlation is probably insufficient to allow accurate prediction of these parameters for an individual patient. It is not possible to delineate reliably the effects of dust exposure from other relevant factors. Further research is still required in these areas.

Please note that a longer version of this article is available as Supplementary data at Occupational Medicine Online.
Conflicts of interest

The authors have not received any financial support for this study or been involved with any organizations with financial interest in the subject matter.

References


