Evaluation of Paranasal Sinus Mucosa in Coal Worker’s Pneumoconiosis

A Computed Tomographic Study

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Objective: To evaluate by computed tomographic scanning the paranasal mucosal changes of coal workers with and without pneumoconiosis.

Methods: Examination of images and scores from paranasal computed tomographic scans. The study participants were 26 coal workers with pneumoconiosis, 29 coal workers without pneumoconiosis, and 20 controls. All were men. The extent and patterns of inflammatory paranasal sinus disease were evaluated on computed tomographic scans by 2 radiologists using the terminology and definitions of Newman and associates.

Results: Interobserver agreement for the presence of abnormalities was from good to excellent (κ, 0.63-0.89). The mucosal scores of individuals and groups were higher for coal workers than for control subjects. Both scores were significantly higher in the pneumoconiosis group than in the 2 other groups.

Conclusions: This study shows that paranasal sinuses were affected more severely in coal workers than in control subjects. In coal workers with pneumoconiosis, the affection was most severe. The relationship between coal dust exposure and paranasal mucosal changes needs further study.

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The UPPER AND LOWER AIRWAYS are both directly subjected to the adverse effects of coal dust. Chronic inhalation of coal dust can cause several lower airway disorders, including simple coal workers’ pneumoconiosis, progressive massive fibrosis, chronic bronchitis, lung function loss, and emphysema.1 However, it is uncertain whether chronic exposure to coal dust might also lead to inflammatory changes in paranasal sinuses, one of the main components of the upper airway. Air-fluid levels in a sinus usually correlate with acute sinusitis, whereas mucosal thickening usually corresponds to chronic sinusitis.2 The vast majority of the paranasal computed tomographic (CT) studies have shown that the CT scan provides an objective and accurate assessment of mucosal changes in paranasal sinuses.3 To the best of our knowledge, there is no published CT study demonstrating sinus mucosal changes in coal workers.

We designed a cross-sectional randomized study to determine the sinus mucosal changes in coal workers with and without pneumoconiosis. We suspected that chronic irritation due to coal dust particles would cause chronic sinus changes more commonly in coal miners with pneumoconiosis than in those without and in individuals living in the community.

METHODS

The present study involved examination of CT scans and scores for 26 coal workers who had pneumoconiosis (group 1), 29 coal workers without pneumoconiosis (group 2), and 20 controls from the community (group 3). All were men. Chest radiographs were examined by 2 “B” readers (readers who have successfully completed a certification examination and must be recertified every 4 years) using the 1983 International Labour Office (ILO) classification of radiographs of pneumoconioses.4

All study participants were recruited from the Karadon area of the Zonguldak Coal Basin, which has 5 areas of coal production. All coal workers spent 6 hours per day, 5 days per week, and 26 weeks per year underground, and all coal workers, with or without pneumoconiosis, had an exposure duration of at least 10 years. The mean proportions of the chemical components of the coal extracted from the Karadon mines are 55% carbon, 26% volatile substances, 11% ash, and 8% moisture. The mean annual dust concentrations are between 0.5 and 7.2 mg/m³, depending on the location. All data were obtained from the Turkish Coal Company. All coal workers underwent yearly clinical and radiological examinations, and the chest
radiographs of coal workers with pneumoconiosis showed ILO profusion scores of 0/1 to 2/2. The measured values of particulate substances and gases in the air in the city of Zonguldak were slightly higher than the World Health Organization standards in the winter season (eg, the mean air concentration of sulfur dioxide was 148 mg/m³ in the winter whereas the World Health Organization standard is 125 mg/m³). Air quality data were obtained from the Zonguldak Meteorology station.

The study was accepted as a project by the Karaelmas University Medical School and data were collected from May 2002 to March 2003. Informed written consent was obtained from all subjects. At the time of presentation, a careful history was obtained with attention to the presence of symptoms, current intake of medications, and previous surgical interventions. The participants’ demographic characteristics such as age, duration of exposure, and smoking status were recorded. Individuals who had symptoms of active rhinosinusitis, allergic rhinitis, a severe septal deviation, or a history of sinonasal surgery, or who had followed a medical treatment in the past month were excluded from the study.

**CT TECHNIQUE**

Computed tomographic scans were performed on a spiral CT machine (Philips Secura, Best, the Netherlands). A lateral computed radiograph was initially obtained, and the gantry was aligned perpendicularly to the hard palate. Spiral scanning with a 2-mm collimation and a 3-mm/s table feed (pitch factor, 1.5) was performed from the frontal sinuses to the sphenoid sinuses. The images were then reconstructed using a bone algorithm.

**EVALUATION CRITERIA**

The extent and patterns of inflammatory paranasal sinus disease shown on the CT scans was evaluated and scored by 2 radiologists using the terminology and definitions of Newman and associates. Nasal passage and sphenoid sinus are regarded as a single unit in the Newman et al classification. Nasal passage and ostiomeatal complex scoring was based on the degree of obstruction. Sinus scores (2 frontal, 2 maxillary, 2 ethmoid, and 1 sphenoid) were based on mucosal thickening measured at the site of maximal thickness. Actual millimetric measurements were performed at a workstation provided by the CT scanner vendor (Easyvision, software program, Philips). Individual scores were from 1 to 3 depending on mucosal thickness or obstruction (0 = minimum, 3 = maximum). Thus, a maximum total score of 30 points was possible (21 from the sinuses, 6 from the ostiomeatal complexes, and 3 from the nasal passages). The total CT scores were used to classify the patients as having limited (CT score, 0 ≤ 11) or extensive disease (CT score ≥ 12). Examples of scores are shown in **Figure 1** and **Figure 2**.

**STATISTICAL ANALYSIS**

Results were evaluated using the SPSS statistical program, version 11.0 (SPSS Inc, Chicago, Ill). The difference between the means of variables in 2 groups was tested with the independent sample *t* test. The difference between the means of variables in more than 2 groups was evaluated with the Kruskal-Wallis test. The effects of demographic factors (age, exposure duration, and smoking) on total scores were tested by multiple regression analysis. Significance was set at the 5% level (*P* < .05). All measured values are given as mean ± SD.

**RESULTS**

All of the scan images were of diagnostic quality, and the interobserver agreement for the presence of abnormalities was good to excellent (κ, 0.63-0.89).
The participants’ demographic characteristics are shown in Table 2; there were no differences between the groups regarding age, duration of exposure, and smoking.

Disease severity in the 3 groups is shown in Table 3. Extensive disease was more common in group 1 than in group 2 (in 35% vs 24% of individuals), but there was no statistically significant difference (P > .05). Individual mucosal scores for nasal passages scores and all paranasal sinuses except for sphenoid sinuses, as well as the total mucosal scores, were higher in group 1 and group 2 than in group 3 (Table 4). Group 1 had the highest total mucosal scores.

Multilinear regression analysis did not reveal any effect of age and smoking on paranasal sinus scores (P > .05), but there was a positive correlation for coal dust exposure duration (r = 0.44; P < .05) (Figure 3).

There are many studies to document the adverse effects of coal dust on the lower airways, including simple coal workers pneumoconiosis, progressive massive fibrosis, chronic bronchitis, lung function loss, and emphysema. However, there is no published study showing the effect of chronic coal dust exposure on paranasal sinus mucosa.

The role of CT studies of the paranasal sinuses for the assessment of chronic rhinosinusitis has undergone extensive evaluation. Evaluation has included tests for CT sensitivity and specificity compared with plain films of the sinuses, as well as attempts at correlating CT scan findings with clinical symptoms, operative findings, and even allergy and blood testing. The vast majority of these studies have shown that the CT scan provides an objec-

tive and accurate assessment of inflammatory disease of the paranasal sinuses. The severity of chronic sinusitis was evaluated by many CT studies using various scoring systems. None of them is strictly superior to another. We used the CT scoring system of Newman and associates in this study.

Many factors can cause paranasal mucosal thickening besides coal dust exposure, and we were careful to exclude factors that may bias the study results, such as recurrent infections, a history of sinus surgery, or severe septal deviation. Allergy is also considered to be an important cause of mucosal inflammation, edema, and obstruction. Early studies suggested that sinusitis was more common in allergic individuals than in control subjects. We differentiated and excluded confounding factors as much as possible by means of history taking, endoscopic examination, and total IgE evaluation.

Smoking may affect sinus mucosa by directly causing mucosal inflammation, or by indirectly affecting mucociliary clearance, thereby causing predisposition to sinus infection. Most of the subjects in the 3 groups were smokers, and there was no significant difference among the groups, which, we suppose, decreased the bias introduced by smoking. Parallel to this result, with multiple regression analysis, smoking was not found to have an effect on paranasal sinus scores (P > .05). Age and exposure duration may also have an effect on sinus mucosal scores, but our study participants were all middle-aged and no correlation was obtained between age and total mucosal scores (P > .05). On the other hand, there was a positive correlation between coal dust exposure duration and total mucosal scores (r = 0.44; P < .05).

In our study, most of the individual mucosal scores and total mucosal scores were significantly higher in coal workers than in apparently healthy city dwellers. Interestingly, however, 3 subjects in the control group (group 3) had high disease scores and the mean total score was 4.7 in that group. This elevated mean score could be partly related to their relatively high smoking scores. Moreover, air pollution in Zonguldak might also have an effect on mucosal scores. The mechanism of mucosal thickening secondary to coal dust exposure is not well known, and we present a theoretical discussion of this issue according to the literature. Our hypothesis is that long-term coal dust exposure on paranasal mucosa can cause mucosal irritation leading to mucosal inflammation, which is seen as mucosal thickening on CT scans.

It is well known that mucosal inflammation of sinuses is characterized by the infiltration of inflammatory cells.

### Table 2. Demographic Characteristics of Coal Workers and Controls*

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Coal Workers With Pneumoconiosis</th>
<th>Coal Workers Without Pneumoconiosis</th>
<th>Controls</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td>41 ± 3 (36-47)</td>
<td>40 ± 3 (33-45)</td>
<td>35 ± 4 (28-41)</td>
<td>&gt; .05</td>
</tr>
<tr>
<td>Duration of exposure to coal dust in the mine, y</td>
<td>15 ± 3 (10-20)</td>
<td>13 ± 4 (10-18)</td>
<td>. . .</td>
<td>&gt; .05</td>
</tr>
<tr>
<td>Smoker-nonsmoker ratio (%)</td>
<td>24/29 (83)</td>
<td>14/20 (70)</td>
<td>. . .</td>
<td>&gt; .05</td>
</tr>
<tr>
<td>Smoking history, pack-years†</td>
<td>18 ± 8 (5-45)</td>
<td>21 ± 17 (6-90)</td>
<td>15 ± 8 (3-30)</td>
<td>&gt; .05</td>
</tr>
</tbody>
</table>

*Values are given as mean ± SD (range) unless otherwise indicated.
†These values only concern smokers.

### Table 3. Disease Severity in All Groups

<table>
<thead>
<tr>
<th>Group</th>
<th>Disease Severity, No. (%)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Limited</td>
<td>Extensive</td>
<td>Total</td>
<td></td>
</tr>
<tr>
<td>Coal workers with pneumoconiosis</td>
<td>17 (65)</td>
<td>9 (35)</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>Coal workers without pneumoconiosis</td>
<td>22 (76)</td>
<td>7 (24)</td>
<td>29</td>
<td></td>
</tr>
<tr>
<td>Controls</td>
<td>17 (85)*</td>
<td>3 (15)</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>56 (75)</td>
<td>19 (25)</td>
<td>75</td>
<td></td>
</tr>
</tbody>
</table>

*In 2 of the 17 controls the computed tomographic scan did not reveal any mucosal abnormality.
cells such as neutrophils, macrophages, lymphocytes, and eosinophils. There is now considerable evidence that certain cytokines and endothelial cell adhesion molecules, induced in part by tumor necrosis factor (TNF)-α, may be implicated in the pathogenesis of this type of inflammation.1 Cytokines have an important role in the pathogenesis of chronic sinusitis because (1) they are chemotactictractants for neutrophils and monocytes; (2) they increase microvascular permeability; and (3) they activate T cells, mast cells, and eosinophils.11 Primary target cells of inhaled coal dust particles are macrophages and epithelial cells. Activated macrophages produce excessive amounts of cytokines (interleukins and TNF-α).12 Chronic paranasal inflammation may also impair the function of ciliated cells, which leads to increased incidence of paranasal infections and results in mucosal thickening.13

Mucosal scores were highest in coal workers with pneumoconiosis, and extensive disease scores were also highest in this group. It is now well known that cytokines, in particular TNF-α, are of primary importance in the development of pneumoconiosis. In a 5-year follow-up study, Schins and Borm14 have shown that coal workers with pneumoconiosis (Group 1), without pneumoconiosis (Group 2), and controls (Group 3)

Figure 3. Correlation between exposure duration and total mucosal scores of coal workers with pneumoconiosis.

Table 4. Comparisons of Paranasal Sinus Mucosal Scores Between Coal Workers With Pneumoconiosis (Group 1), Without Pneumoconiosis (Group 2), and Controls (Group 3)

<table>
<thead>
<tr>
<th>Sinus/Passage</th>
<th>Mean ± SD Score</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group 1</td>
<td>Group 2</td>
</tr>
<tr>
<td>Frontal</td>
<td>2.4 ± 1.0</td>
<td>1.8 ± 1.5</td>
</tr>
<tr>
<td>Maxillary</td>
<td>2.7 ± 2.0</td>
<td>2.0 ± 1.8</td>
</tr>
<tr>
<td>Sphenoid</td>
<td>0.8 ± 0.9</td>
<td>0.6 ± 0.9</td>
</tr>
<tr>
<td>Ethmoid</td>
<td>3.0 ± 2.0</td>
<td>2.2 ± 2.0</td>
</tr>
<tr>
<td>Osteomeatal complex</td>
<td>1.9 ± 2.0</td>
<td>1.2 ± 1.7</td>
</tr>
<tr>
<td>Nasal passage</td>
<td>0.7 ± 0.8</td>
<td>0.5 ± 1.0</td>
</tr>
<tr>
<td>Total score</td>
<td>12.3 ± 7.0</td>
<td>8.6 ± 6.2</td>
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In conclusion, this study shows that paranasal sinus scores and the presence of pneumoconiosis in coal workers.

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REFERENCES


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