Definition of radiographic patterns of the silicosis in Mongolia according to the ILO International classification

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Abstract

We involved in this study 247 patients who worked at the “Bor-Undur” underground spar mining and were diagnosed as having occupational lung diseases; and their 30 chest radiographs with evidence of silicosis. The mining employs 1500 employees, 350 of that work at underground mining. There are totally 247 patients from “Bor-Undur” spar mining and processing plant, who have been diagnosed as having occupational lung diseases and compensated during 1995-2010, and these 247 patients are under medical follow-up of the National Center for Labor Conditions and Occupational Diseases study.

Silicosis is a type of pneumoconiosis and caused by inhalation of crystalline silica dust. When small silica (also known as silicon dioxide (SiO_2)) dust particles are inhaled, they can embed themselves deeply into the tiny alveolar sacs and ducts in the lungs. When fine particles of silica dust are deposited in the lungs, macrophages that ingest the dust particles will set off an inflammation response by releasing inflammatory factors, in turn, these stimulate fibroblasts to proliferate and produce collagen around the silica particle, thus resulting in fibrosis and the formation of the nodular lesions; and further respiratory-heart failure and lung cancer [1]. For this reason, the silicosis still attracts attention in many countries of the world among the occupational health issues.

In our country, intensive industrialization of mining has led to an increase in silicosis cases.

By our study, silicosis mostly occurs among penetrators and drillers or in 56.7% of the workers. In 73.3% of the workers, silicosis is diagnosed 14.8±3.5 years after employment in dusty environment with silicon dioxide. On the chest X-ray: using the ILO classification system, small, rounded opacities (of 1.5-3 mm) or shape/size "q" compose 76.6% and small, irregular opacities classified by width as "t" compose 66.6%. In our country, silicosis cases of small opacities are higher than that of large opacities. Among them, nodular opacities are predominant over interstitial abnormalities.

Key words: mining industry, particles of silica dust, pneumoconiosis, parenchymal abnormalities

Study background

There, in Mongolia, non-ferrous metal, minerals and coal industry is running intensively due to the high demand for mineral resources and raw materials in the world market. In the course of this industrial process, factors influencing negatively on human organism permanently appear.

Silica dusts arise during the process of minerals' mining such as gold, copper, quartz containing ores, coal, spar, iron, and machinery, ceramics, construction, iron and steel, stone facet and cutting industries. Silicosis is a type of pneumoconiosis and caused by inhalation of industrial dust particles containing silicon dioxide. When small silica dust particles are inhaled, they are deposited in the lungs which stimulate fibroblasts to proliferate and produce collagen around the silica particles, thus resulting in fibrosis and the formation of the nodular lesions; and further respiratory-heart failure and lung cancer [1].

Although silicosis incidence has decreased in countries where prevention is proper, it still remains as one of the most common diseases among occupational diseases in many countries of the world. As of 2007, in the USA 1.7 million workers have had occupational exposure to crystalline silica dust, and in China 500,000 cases of silicosis have been diagnosed in 1991-1995 [2].

In 1997, the International Agency for Research on Cancer included crystalline silica into the group of carcinogenic agents to humans. Morbidity, loss of work ability and mortality due to silicosis have become actual world widely, consequently, in 1995 the WHO/ILO Joint Committee on Occupational Health launched "Global program on Elimination of Silicosis" the aim of which was to eliminate Silicosis from the world by the 2030 [2].

In our country, intensive development of mining industry facilitates spread of silicosis. "Bor Undur" spar mining that is enrolled in this study is started up in 1985 and runs spar mining and beneficiation. The mining employs 1500 employees, 350 of that work at underground mining. An average of 65 samplings of the overall dust amount was 12.86 mg/m^3, which was 6 times greater than the Permissible Exposure Limits [7].

Studying specific radiographic features of pneumoconiosis occurred in our country is important for approaching its diagnosis to the international standard, early detection and prevention from complications. This study carried out first time in Mongolia and it would help to evaluate radiographic abnormalities in correct ways, improve quality of diagnosing and bring diagnosing of pneumoconiosis to the international level. As well as, we expect quality of the prevention and early detection of occupational diseases, including pneumoconiosis would be improved in our country with help of this study.

Purpose of the study

The aim of the study is to determine specific radiographic patterns of silicosis using the International radiological classification of pneumoconiosis.

Objectives of the study

1. To define opacity types on chest radiographs of the patients with evidence of silicosis according to the international classification
2. To determine duration of exposure to dust, age and profession of people with silicosis

Study methodology

The study was conducted by the cross-sectional study of statistics. Database was set using “MS Excel” programs basing on the collected data. Statistical processing of quantitative database was done by “SPSS-12.0” program. Disparity in structural parameters of the study was evaluated by Chi-square (X^2).

Study materials

1. 247 cases diagnosed as occupational lung disease from employees “Bor Undur” spar mining
2. X-ray films of 1995-201O on that based silicosis diagnosis
3. Study cards

Study method

Study was done according to the ILO International radiological classification of Pneumoconiosis using above mentioned study materials. The International radiological classification is used for systematic recording of lung abnormalities on chest radiographs due to inhalation of industrial dust and for health surveillance of employees. Objective of this classification is to codify the radiographic abnormalities of pneumoconiosis in simple and easy way [6].

Chest radiographs were evaluated in comparison with ILO AP chest standard radiographs. Parenchymal abnormalities, opacities and profusion on the radiographs are signed by the following letters: *small round opacities* are recorded as p, q, and r depending on their sizes; *small irregular opacities* are recorded as s, t and u.

p = diameter ≤ 1,5mm; **q** =1,5 mm< diameter≤ 3mm; **r** = 3mm< diameter ≤10mm
s = width ≤ 1,5mm; **t** = 1,5 mm < width ≤ 3mm; **u** = 3mm < width ≤10mm
Shape and size of small opacities in a radiograph are codified in 2 letters. All opacities are of one shape and size recording symbol twice, as q/q. Another shape or size is seen recorded as second letter q/t, in this case small round opacity of 1.5-3mm in size is predominant, but small irregular opacity of 1.5-3mm in width is significant.

For definition of the opacity profusion we divide lungs into 6 standard zones. Horizontal lines at 1/3 and 2/3 of vertical distance between apices and diaphragm divide lungs into 6 zones: right upper, right middle, right lower and left upper, left middle, left lower. Profusion was classified by lung zone coverage using 12-point scale as 0/-, 0/0, 0/1, 1/0, 1/1, 1/2, 2/1, 2/2, 2/3, 3/2, 3/3, 3/+. If small opacities are absent then 0/-, less profuse than lower limit of category 1 - 0/0, if small opacities can be recorded as category 0, but profusion approaches to the category 1 then 0/1 so on. Dense, combined area profusion is recorded as 3/+.

Abnormal opacities greater than 10mm in diameter are classified as *large opacities* and recorded in letters of A. B. C. **A** category includes 10-50mm single opacity of the greatest diameter, or each greater than 10mm and sum of diameters ≤50mm several opacities. **B** category: larger or numerous than A category, and combined area ≤ right upper zone. **C** category: combined area > right upper zone single and several opacities.

Study outcome

Occupational lung disease diagnosed in employees of the "Bur-Undur" spar mining

From employees of the "Bor Undur" spar mining silicosis and bronchitis caused by dust have been diagnosed in 247 people totally, from 1995 to 2010. Out of them silicosis was 31 (13%) and dust bronchitis - 216 (87%).

Among total people in follow-up, women were 9.7% (24) and men - 90.3% (224). 71.7% (178 people) of the total had worked at the "Bor Undur" spar mining for 10-19 years when silicosis and dust bronchitis were diagnosed; and consequently they have been compensated on loss of work ability.

Correlation between silicosis development and employees' duration of exposure to dust, ages and professions

We selected 30 silicosis cases among occupational lung diseases diagnosed in 1995-2010 and studied employees' duration of exposure to dust, and their ages and professions.

Silicosis occurred among penetrators in 30%, drillers in 26.7% and operators of heavy industries, blasters, breakers and loaders in 6.7%, and plumbers, diggers and masters in 3.3% relatively (Table 1). Incidence was higher among penetrators and drillers compared to workers of other occupations ($p<0.01$).

Table 1

№	Occupation	Cases	
		n	%
1	Spar sorter	2	6.7
2	Operator	2	6.7
3	**Penetrator**	9	**30.0**
4	Blaster	2	6.7
5	Breaker	2	6.7
6	**Driller**	8	**26.7**
7	Master	1	3.3
8	Loader	2	6.7
9	Plumber	1	3.3
10	Digger	1	3.3
Total		30	100.0

1. In 73.3% of the workers, silicosis was diagnosed 14.8±3.5 years after employment in dusty environment with silicon dioxide. It was earlier by 4-5 years than dust bronchitis development in workers of the Power Plant-4 (after 18-25 years' exposure to dust) (Table 2).

Table 2

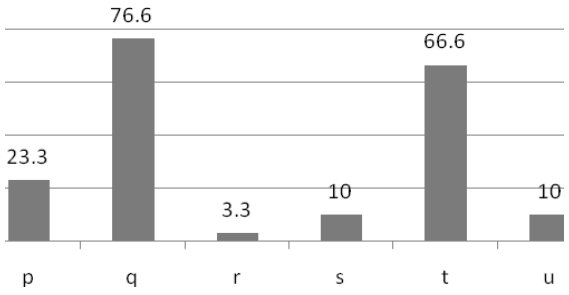
№	Worked years	Case number	%
1	8-11	5	16.7
2	12-15	12	40.0
3	16-19	10	33.3
4	20-23	3	10.0

2. An average age at which silicosis diagnosed was 40.4±4.9 years.

Lung parenchymal opacity types

1. On the chest X-ray, small, rounded opacities "q" or round opacities of 1.5-3mm in diameter composed 76.6% and "t" or small, irregular opacities of 1.5-3mm in width composed 66.6%. Consequently, silicosis cases of small opacities or of the "symptom of a snowstorm" occurred more frequently (Picture 1).

2. Small, rounded opacities of <1.5mm in diameter or “p” opacities occurred in 23.3% and round opacities of 3-100mm or “r” opacities were revealed in 3.3%.
3. Thin irregular opacities of 1.5 мм or “s” opacities and thick irregular of 3-10mm or “u” opacities occurred in 10% in each.

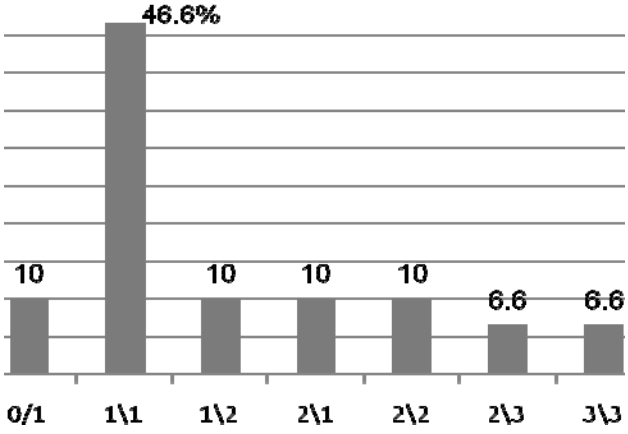


Picture 1: Small opacities in the lungs (%)

4. Large opacities of “A; B; C” occurred in 10% in total.

Opacity profusion in the lung parenchyma

By our study, 1/1 or in 46.6% of the cases, profusion of opacities was at 1/3 of the vertical distance. It shows that 40% of the total diagnosed cases of silicosis in our country were detected in their late phases (Picture 2).



Picture 2: Profusion of opacities in the lungs (%)

Additional opacity features from lung and heart sides

By evaluation of the additional opacities from lungs and heart, calcification of hilar lymphatic nodes were revealed in 60%, chronic pulmonary heart disease in 43.3%, mediastinal lymphatic nodule enlargement in 30%, pleural thickening in the interlobar

fissure in 26.6% and emphysema in 26.6%. Tuberculosis associated in 13.3% of cases (Table 4). Among silicosis complications, cor pulmonale and emphysema occurred mostly.

Table 4

	Symbols	**Case number**	**%**
aa	Atherosclerotic aorta	5	16.6
at	Significant apical pleural thickening	3	10
cg	Calcification of lymph nodes	17	60
cn	Calcification of pneumoconiotic nodule	5	16.6
co	Abnormality of cardiac size or shape	13	40
cp	Cor pulmonale	15	43.3
em	Emphysema	8	26.6
es	“Egg shell calcification”	1	3.3
hi	Enlargement of hilar or mediastinal lymph nodes	9	30
pi	Pleural thickening in the interlobar fissure	8	27
tbi	Inactive tuberculosis	4	13.3

Discussion on the study outcome

By the study of Janet M.Hughes and Robert N. Jones of the Washington University, USA and the University of British Columbia, Canada: silicosis of small opacities were 95%, of large opacities – 5%, profusion of small opacities in 66.2% was >1/1 and in 36.6% was 1/0 [4]. By our study, silicosis of small opacities were 90%, of large opacities – 10%, thus, the result is similar to the outcome of the above mentioned study. In our country, profusion of small opacities of 1/1 was common.

The study by S.M Jain and K.C Khare showed that in 9% of patients with silicosis was diagnosed emphysema (em) and in 11% - enlargement of hilar lymph nodes [5]. By our study, emphysema was 26.6%, enlargement of hilar lymph nodes 30% which means pulmonary heart complication was common. By the study of S.M Jain et al, small round opacities (p; q; r) were 67%, small irregular dash-formed opacities (s; t; u) - 35%, and large opacities (A; B; C) - 20% [5]. By our study also, small round opacities occurred more frequent than irregular opacities which similar to that of foreign researchers. Large opacities or progressive massive fibrosis were 10% which less than that of foreign researchers.

By the study of the National Occupational Health Center of India in 2003, in 17.9% of the patients with silicosis occurred silicosis alone, in 23.9% - silicotuberculosis was diagnosed [3]. In our country, silicotuberculosis observed in 13.3% that is less than that of Indian researchers.

Conclusion

1. Silicosis mostly occurred among penetrators and drillers. Spar mining employees more exposed to occupational lung disease at their young ages compared to the employees of the Power Plant-4.
2. There, in our country, small round opacities of the pneumoconiosis predominant over the irregular dash-formed opacities on the chest radiographs. Small opacities occurred more than the large opacities.

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