ORIGINAL RESEARCH PAPER

Radiodiagnosis

RADIOLOGICAL EVALUATION IN SILICOSIS PATIENTS BY CHEST RADIOGRAPH, HRCT/CECT CHEST AND CORRELATION WITH PULMONARY FUNCTION TEST

KEY WORDS: Silicosis, Tomography, Pulmonary function test

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ABSTRACT

Objectives- To assess pattern and extent of various radiological lesions detected on chest radiography and HRCT chest and its correlation with pulmonary function tests. **Methods –** 59 workers exposed to silica underwent CR, HRCT, and pulmonary function tests. HRCT grading system described by presence, size and distribution of nodules and relative parenchyma & vascular markings in 59 subjects. **Results –** Concordance between readers was higher for HRCT than for CR in the early stages of silicosis. No significant difference in pulmonary function tests was found among different CR categories, but forced expiratory volume in one second (FEV1), FEV1/FVC ratio, FVC and diffusion capacity significantly decreased with increasing HRCT categories and large opacities than with that of small opacities on chest radiography. Subjects with conglomerated silicosis showed higher residual volume and functional residual capacity than subjects with simple silicosis. **Conclusion-** HRCT is more reproducible and accurate than CR, as suggested by the higher agreement between readers and the better correlation with pulmonary function tests. However, these data do not support the hypothesis that HRCT is more sensitive than CR in the early detection of silicosis.

INTRODUCTION

Estimation of disease severity in silicosis conventionally involves a combination of radiographic and pulmonary function assessment. The chest radiograph is used to detect the characteristic interstitial changes and lymphadenopathy. Pulmonary function tests are the basis for assessing functional limitation. Description of the CT appearance of silicosis in radiologic literature has been limited. Computed tomography (CT), however, has proven superior to the chest radiograph in the early detection of pulmonary nodules [3] and interstitial changes [4]. The advantage of decreased superimposition of parenchymal structures provided by using thin CT slices in the transaxial plane allows clear visualization of the distribution and severity of parenchymal changes [4, 5]. To describe the range of abnormalities in silicosis visible by CT and to compare disease extent assessed by CT with that estimated from the ILO classification of radiographs and pulmonary function, we performed CT, chest radiography, and pulmonary function tests on 59 patients with silicosis.

Subjects and methods

SUBJECTS

We studied 59 subjects (56 men, 3 women; 17 smokers, 23 non-smokers, 19 ex-smokers) with mean (SD) age of 44.1±11.07 years. All of them had been exposed to silica dust in mines, in glass and pottery industries, and in the building industry. Most of them had been diagnosed as having silicosis, based on a history of exposure to silica and radiographic changes consistent with silicosis (presence of rounded or irregular small opacities with profusion > 1/0 on the International Labour Office (ILO) classification).

CHEST RADIOGRAPHY

Standard high kilo voltage posteroanterior CR was carried out at maximal inspiration. The posteroanterior view of each film was graded for the profusion of opacities according to the ILO-2000 classification by two experienced observers separately. To group patients with similar profusions of disease, four categories were defined on the basis of the same ILO profusion grades: category 0 = profusion grades 0/-, 0/0, 0/1; category 1 = profusion grades 1/0, 1/1, 1/2; category 2 = profusion grades 2/1, 2/2, 2/3; category 3 = profusion grades 3/2, 3/3, 3/+, associated or not with coalescence. In the presence of a discrepancy between the two readers (difference in the CR categories > 1), the CR films were read by the two readers together and a final evaluation was reached.

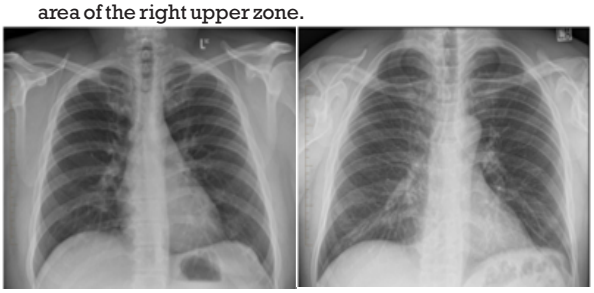
Small opacities were coded as p, q, and r, corresponding to <1.5 mm, 1.5–3 mm, and 3–10 mm sizes respectively; irregular opacities were coded as s, t, and u, corresponding to <1.5 mm, 1.5–3 mm, and 3–10 mm sizes, respectively.

Opacities larger than 1 cm were recorded as large opacities using the following code:

- A was coded if the sum of the large diameters of these opacities was 1–5cm,
- B was coded if the sum was >5 cm and did not pass the right upper zone, and

Fig.1 - Silicosis on CT. A, Grade I: scan through carina in patient with mild silicosis. A few nodules are present, with otherwise normal lung parenchyma. B, Grade II: Many nodules are present, but without confluence. c, Grade III: Confluence of nodules is seen, associated with some disruption of vascular markings on right. Nodules are predominantly posterior in distribution. Paraseptal bullae are present in right lung adjacent to mediastinum. D, Grade IV: Dense confluence of nodules extended over four CT slices. This was considered consistent with progressive massive fibrosis. Calcification is also present within hilar nodes.

- C was coded if one or more opacities cross the equivalent area of the right upper zone.



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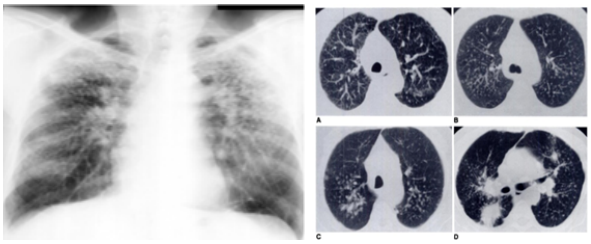

HIGH RESOLUTION COMPUTED TOMOGRAPHY - High resolution computed tomography scans were obtained in the supine position by means of a 16 slice Philips tomograph. The HRCT was performed with breath held after deep inspiration and a 1-1 5 mm section thickness at 10 mm intervals from the apex to the base of the lungs. All HRCT images were graded by the same two readers separately, according to the criteria of Bergin et al for the profusion of the parenchymal opacities.'8 Briefly, they were classified in five categories as follows: category 0 = no definite nodules; category 1 = small number of nodules without disruption of vascular markings; category 2 = many definite nodules, but with no confluence; category 3 = confluence of nodules with disruption of vascular markings; category 4 = confluence of nodules extending over two or more slices.

Pulmonary Function Testing

All subjects performed tests of spirometry, diffusing capacity, and lung volumes. Maximum forced vital capacity (FVC) maneuvers were performed as recommended by the American Thoracic Society [9. Testing was done on RMS Helicos 401 spirormeter . Single-breath carbon-monoxide diffusing capacity (DCO) is also measured.

RESULTS

The pulmonary function tests in the patients with silicosis are summarized in table 1. Slight to moderate impairment prevailed.

There was a mild concordance between CR and HRCT categories of parenchymal opacities. The largest discrepancy occurred in the 0 and 1 categories.

On comparison of Chest X-ray grading and HRCT grading of silicosis among 59 patients, we observed that 19 patients (32%) were found to have same grading on both Chest X-ray and HRCT. Seven patients classified as grade "0" based on Chest X-ray, finding were reclassified as grade "I" based on HRCT. Similarly one patient that was classified in category "0" on Chest X-ray was reclassified as category "II" on HRCT. Eight patients classified as grade "1" on Chest X-ray, were reclassified as grade "II" on HRCT.

The diagnosis of PMF was made based on chest x ray finding in 9 cases, compared to 19 cases by HRCT findings. Only 9 patients showed progressive massive fibrosis on both Chest X-ray and HRCT. Thus HRCT detect the presence of the coalescence or conglomeration in silicosis better than chest X-ray.

Silicosis (category 0, 1, 2) does not produce significant impairment in lung function however category 3 and PMF show impairment in lung function'. In our study, the mean FVC, FEV1, FEV1/FVC ratio and DLco (%predicted) of patients with grade 0 was 96.14±6.57, 93.36±8.02, 85.64±13.77% and 87.43± 7.85 respectively, all parameters were within normal limits & gradually decreased with increasing ILO grading to 45.0±12.38 (%predicted), 36.2±8.64 (%predicted), 63.67±5.52% and 41.1±9.75 (%predicted) respectively in grade C of patients having PMF, all these change in parameters were highly significant (p<0.001 silicosis by HRCT 86.2 ((categories 1 and 2) and subjects with conglomerated silicosis (categories 3 and 4) showed lower FEV1 and expiratory flows compared with subjects of silicosis (category 0), but subjects with conglomerated silicosis had higher values of RV and FRC than subjects with silicosis (category 1and) . in our study the mean FVC, FEV1, FEV1/FVC ratio and DLco (%predicted) of patients with grade 0 was 98.33±4.41, 95.83±8.15, 88.83±11.77% and 91.17±6.82 respectively, all parameters were within normal limits & gradually decreased with increasing HRCT grading to 51.85±12.70, 43.85±1.02, 65.95±6.88% and 45.25±10.12 respectively in grade 4 of PMF patients in our study (p<0.01).

Table 1:- Pulmonary function tests in patients with silicosis:

Parameters	Mean value	SD	Range
FVC (%predicted)	70.2	21.0	28-106
FEV1(%predicted)	66.9	23.2	20-108
FEV1/FVC %	74.5	13.6	52-102
DLco(%predicted)	65.7	19.4	30-100

Table 2:– Correlation in between the radiological and tomographic categories among silicosis patients:

Chest x-ray grading	HRCT-Grading					Total	p value
	0	1	2	3	4		
0	6	7	1	0	0	14	<0.01
1	0	1	8	1	0	11	
2	0	0	5	3	3	11	
3	0	0	0	7	7	14	
C	0	0	0	0	9	9	
Total	6	8	14	11	20	59	

Table 3:- Functional indices according to the radiographic categories of small and large opacities among study subjects:

Parameters	Chest X-ray grading					p value
	0	1	2	3	Type C	
Mean FVC (% predicted)	96.1±6.5	79.3±13.2	64.9±14.2	57.7±12.3	45.0±10.3	<0.01
Mean FEV1 (%predicted)	93.3±8.0	78.9±14.2	59.0±21.2	57.0±10.8	36.2±8.64	<0.01
FEV1/ FVC (%)	85.6±13.7	77.0±15.4	71.7±9.0	70.8±11.6	63.6±5.52	<0.01
Mean Dlco (% predicted)	87.4±7.8	76.5±12.8	62.1±14.0	54.2±10.6	41.1±9.75	<0.01

Table 4:- Functional indices are according to the tomographic categories:

Parameters	HRCT-GRADING					p value
	0	I	II	III	IV	
Mean FVC (%predicted)	98.3±4.4	94.2±8.3	79.5±12.9	59.2±11.1	51.8±12.7	<0.01
Mean FEV1 (%predicted)	95.8±8.1	88.5±12.0	82.5±13.9	57.6±12.2	43.8±1.0	<0.01
FEV1/FVC (%)	88.8±11.7	86.6±13.9	74.7±13.4	73.4±12.6	65.9±6.8	<0.01

Mean DLco (%predicted)	91.1±6.8	85.6±6.9	77.3±7.3	60.0±1 0.3	45.2±1 0.1	<0.01

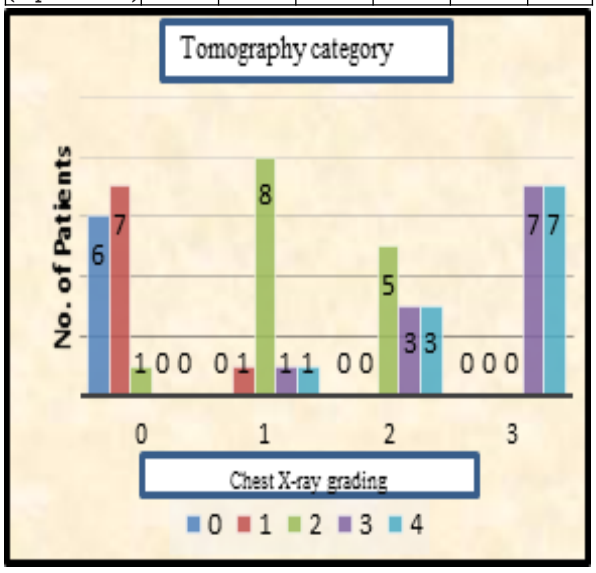

Figure 3:- Distribution of individuals in the radiological and tomographic categories, according to the profusion of small opacities

DISCUSSION

In recent publications there is some disagreement on the concordance between CR and CT in the evaluation of the profusion of lung parenchymal opacities in silicosis, especially in the initial stages. This discrepancy can be partially explained by the lack of a "gold standard" for the diagnosis of silicosis, to some methodological problems related to the technique of analysis, and to interpretation by the readers. A true gold standard for interpretation of x ray films should be the morphology of the lung parenchyma obtained by necropsy or transbronchial or open biopsy. The few data published on this point concern mainly other interstitial lung diseases and only occasional cases of silicosis are reported; furthermore, the relation between CT and morphology was only qualitative, and no comparison was attempted between the profusion of small opacities detected by HRCT and a morphological score of interstitial involvement. Other authors used the mineral content of bronchoalveolar lavage cells as a surrogate of the total lung burden of dust; unfortunately, the technique of this analysis is not completely standardised, and a clear cut off point between normal and exposed subjects has not been reported. This technique, however, could identify the severity of the exposure to dust, but not the degree of the reaction of the lung parenchyma to silica dust. Our data confirm the poor concordance between CR and HRCT in the early stages of the disease. In the absence of a gold standard for the diagnosis of silicosis, it is difficult to decide which technique is more accurate to detect early parenchymal involvement in silicosis. The better concordance between the readers for HRCT than for CR, similar to that reported' despite the absence of ILO type films for the CT images, and the presence of a significant correlation between HRCT categories and pulmonary function tests seem to indicate a better accuracy for HRCT than for CR. The presence of a significant relation between the profusion of the parenchymal opacities evaluated by HRCT, and the pulmonary function tests has not been extensively reported in previous studies. Our study shows that the increasing severity in HRCT categories is associated with progressive deterioration in expiratory flows and diffusion capacity, whereas no relation could be found between CR categories and lung function. This finding has not been previously reported, and supports the argument that HRCT is more accurate in detection of functionally significant pulmonary changes. In particular, category 0 by HRCT selected subjects with normal lung function better than category 0 of CR, whereas higher categories of HRCT are associated with higher abnormalities in lung volumes, expiratory flows, and diffusion capacity .So as HRCT correlates better than CR with pulmonary function tests it can be argued that HRCT is more accurate than CR. Finally, the study of the distribution of the classes of different density of the lung parenchyma detected by HRCT showed significant distinctions only between the extreme categories of HRCT.

CONCLUSION

Our study suggests that HRCT is more reproducible and accurate than CR in the assessment of the severity of pulmonary involvement in silicosis, and in the selection of subjects with different pulmonary functional impairment, although there is no evidence that the sensitivity of HRCT is better than CR in the early detection of silicosis.

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