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DIAGNOSTIC VALUE OF CLINICAL, RADIOLOGIC AND FUNCTIONAL EXAMINATIONS OF PATIENTS WITH PULMONARY AND PLEURAL ASBESTOSIS

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SUMMARY – The aim of the study was to determine sensitivity of individual clinical, radiologic and functional examinations for pulmonary and pleural asbestosis, and their correlations. The study included 180 patients of both sexes. All patients underwent plain and oblique x-rays by so-called "hard" radiography, and 60 patients were additionally examined by high-resolution computed tomography. Functional tests included measurements of vital capacity and diffusing capacity for carbon monoxide. Pleural plaques are a frequent sign of pleural asbestosis. In our study, chest x-rays confirmed the presence of pleural plaques in 25 (41.6%), and high-resolution computed tomography in 51 (85%) out of 60 patients. High-resolution computed tomography detected initial pulmonary fibrosis in 11 (18.4%) of 60 patients with 0/0 and 0/1 perfusion according to the International Labour Organisation classification. Since plain radiology findings in 28 out of 60 patients were not in agreement, it was impossible to make a definite diagnosis of asbestosis. In 22 (36.6%) patients, high-resolution computed tomography indicated initial, and in 6 (10%) moderate fibrosis. In initial asbestosis, vital capacity and diffusing capacity for carbon monoxide are within the normal limits. Only increased profusion of the pulmonary parenchyma opacity and greater extension of the pleural thickening involvement cause a fall in vital capacity.

Introduction

Asbestosis is a disease related to long-time inhalation of asbestos particles. Pathomorphologically, it is a diffuse non-specific interstitial pulmonary fibrosis and pleural thickening. Inhalation of asbestos results in inflammatory reaction of alveolar epithelium and pulmonary interstitial space [1,2].

The clinical symptoms of asbestosis are atypical as it resembles almost all other pulmonary diseases.

Being a progressive disease, it poses a serious medical, labor and social problem. The diagnosis of asbestosis mainly relies on plain chest films in standard and oblique positions made by so-called "hard" radiography. The films are read according to the International Labour Organisation (ILO) classification from 1980[3]. Although the ILO classification improved and standardized radiologic diagnosis of asbestosis, it still remains subjective, particularly in the initial forms of disease. Further, the subjective problems are accompanied by the objective ones related to the chest film reading (technique, sex of patient, obesity and overlapping of pulmonary structures on plain radiography).

The introduction of high-resolution computed tomography (HRCT) has considerably improved the diagnosis, particularly of initial asbestosis[4-6]. The most important functional examinations in asbestosis are vital capacity (VC) of the lungs and diffusing capacity for carbon monoxide (DLco).

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The aim of this study was to find the optimal algorithm especially for early asbestosis.

Patients and Methods

The study included 180 persons of both sexes (100 male and 80 females) exposed to asbestos particles at their workplace. The patients were divided into three groups (Table 1): 1) group with dominantly pleural changes, 2) group with dominantly parenchymal changes, and 3) group submitted to both plain radiography and HRCT.

Anthropometric characteristics and asbestos exposure time in the group of patients with pleural changes are shown in Table 2. The mean age in this group was 51 years, average height 177 cm, and body weight 86 kg. Average asbestos exposure for this group was 29 years.

Table 1. Number of patients with pleural and parenchymal changes, and HRCT scans

	Number (N)	Male n (%)	Female n (%)
Pleura	100	80 (80)	20 (20)
Parenchyma	80	20 (25)	60 (75)
HRCT	60	35 (58)	25 (41)

HRCT = high-resolution computed tomography

Table 2. Patients with pleural changes

Number of patients	100
Mean age (yrs)	51
Average height (cm)	177
Average weight (kg)	86
Asbestos exposure (yrs)	20-35
Average asbestos exposure (yrs)	29

Table 3. Patients with parenchymal changes

Number of patients	80
Mean age (yrs)	49
Average height (cm)	172
Average weight (kg)	69
Asbestos exposure (yrs)	14-34
Average asbestos exposure (yrs)	23

Anthropometric characteristics and asbestos exposure time in the group with parenchymal changes are shown in Table 3. The mean age in this group was 49 years, average height 172 cm, and body weight 69 kg. Average asbestos exposure for this group was 23 years.

Table 4 shows anthropometric characteristics and asbestos exposure time in the group of subjects who underwent both plain radiography and HRCT. The mean age in this group was 49 years, average height 177 cm, and body weight 76 kg. Average asbestos exposure for this group was 27 years.

Table 4. Patients submitted to both plain radiography and HRCT examinations

Number of patients	60
Mean age (yrs)	49
Average height (cm)	177
Average weight (kg)	76
Asbestos exposure (yrs)	21-34
Average asbestos exposure (yrs)	27

HRCT = high-resolution computed tomography

According to ILO classification, 41 patients in the group with pleural changes had changes coded as 3a, 38 patients those coded as 3b, and 21 patients had changes coded as 3c.

The group with parenchymal changes included 45 patients coded by ILO classification as 0/1, 19 as 1/0, 13 as 1/1 and three as 2/1.

Personal history of each patient was taken according to the questionnaire on respiratory diseases recommended by the Committee for Chronic Bronchitis of the British Medical Research Council[7].

Detailed clinical examination was performed by an occupational medicine specialist and a specialist in pulmonary diseases.

All patients underwent plain and oblique x-rays by so-called "hard" radiography using a Superix 800 device. The focus-to-film distance was 180 cm, exposition time 0.03 seconds, current 4 mAs. The voltage on plain radiography was 115 kV, and in oblique position 120-130 kV.

HRCT was performed on a fourth generation Somatom-DRG device (Siemens, Erlangen, Germany). Some patients were examined by use of a Somatom Emotion CT equipment (Siemens, Erlangen, Germany). In all cases, the scanning started from the lung apexes to the lung bases with slice thickness of 1-1.5 mm. The exami-

nation was performed in supine position with deep inspiration, and in suspected cases additional scans were done in prone position. The scanning was conducted on a Somatom DRG (voltage 130 kV, current 180-300 mA, scanning time 3.4 seconds) and spiral CT Somatom-Emotion (voltage 130 kV, current 100 mA, scanning time 0.8 seconds). The scanned sections were photographed in three "windows" for (a) pulmonary tissue, (b) pleura, and (c) pulmonary tissue and pleura.

Functional lung examinations were performed on a Vitalograph (Minhard, England).

Results

Out of 180 patients, 60 underwent both plain radiography and HRCT. We used these two methods to analyze pleural plaques, pleural calcifications and parenchymal changes. The pleural plaques detected by the two methods are shown in Table 5. Pleural plaques were confirmed by plain radiography in 25 patients and by HRCT scanning in 51 patients.

The agreement in detection of pleural plaques between plain radiography and HRCT is shown in Table 6.

Taking HRCT as a reference method for the detection of pleural plaques, out of 60 patients nine had negative and 51 positive findings. Plain radiography recognized all 9 negative findings as negative, so RT specificity was 100%. Out of 51 findings positive on HRCT, radiography recognized only 25, thus the plain radiography sensitivity was 49%. Therefore, the agreement of these two methods for both positive and negative findings was 57%, and disagreement 43%.

Table 5. Pleural plaques on plain radiography and HRCT

No. of patients	x-ray	%	HRCT	%
60	25	41.6	51	85

HRCT = high-resolution computed tomography

Table 6. Agreement of pleural plaque findings between plain radiography and HRCT

		No	Yes	
X-ray	No	9	26	35
Plaques	Yes	0	25	25
		9	51	60

HRCT = high-resolution computed tomography

The Kappa test agreement was only 22.4 %, which is poor agreement.

Detection of pleural calcifications by plain radiography and HRCT is shown in Table 7. It is clear that pleural calcifications were present in six patients on plain radiography, and in 12 patients on HRCT.

The agreement between the findings obtained by these two methods concerning visualization of pleural plaques is shown in Table 8. HRCT found 12 positive and 48 negative findings of pleural calcifications. All negative HRCT findings were also negative on radiography, so the radiography specificity was 100%. Out of 12 positive HRCT findings, only 6 showed positive on radiography, so the radiography sensitivity was 50%. The agreement of these methods was 90% and disagreement 10%.

Table 7. Pleural calcifications on plain radiography and HRCT

No. of patients	x-ray	%	HRCT	%
60	6	10	12	20

HRCT = high-resolution computed tomography

Table 8. Agreement of pleural calcification findings between plain radiography and HRCT

		No	Yes	
X-ray	No	48	6	54
Calcifications	Yes	0	6	6
		48	12	60

HRCT = high-resolution computed tomography

Kappa test was 61.5%, which is good agreement.

A specific problem of plain radiography is evaluation of profusion and size of shadow in asbestosis. The relation between parenchymal changes as *per* ILO classification and those detected by HRCT is shown in Table 9.

So, HRCT determined initial fibrosis in 11 out of 14 patients coded as 0/0 and 0/1. In 28 patients with different classifications that enabled objective confirmation of asbestosis, HRCT determined initial asbestosis in 22 (79%) and moderate fibrosis in six (21%) patients.

The correlation between VC and pleural changes coded under ILO classification is shown in Table 10.

It is obvious that VC value decreases with thickness of pleural involvement. The analysis of variance yielded a significant difference in VC value for all the groups coded under ILO classification.

Table 9. Correlation between parenchymal changes by ILO classification and HRCT

ILO category	No. of patients	HRCT: Interstitial fibrosis		
		mild	moderate	none
0/0, 0/1	14	11	0	3
0/1, 1/0	28	22	6	0
1/1	18	5	13	0
Total	60	38	19	3

ILO = International Labour Organisation; HRCT = high-resolution computed tomography

Table 10. Correlation between vital capacity and pleural changes by ILO classification

ILO	No. of patients	c	SD	Minimum %	Maximum %
3a	41	106.41	12.8	77	133
3b	38	96.95	11.4	75	119
3c	21	88.74	10.1	72	109

c = arithmetic mean; SD = standard deviation; ILO = International Labour Organisation

Table 11. Correlation of vital capacity and level of pulmonary parenchyma shadow profusion

Profusion degree	No. of patients	c	SD	Minimum %	Maximum %
0/1	45	87.40	8.37	69	106
1/0	19	89.94	6.49	80	101
1/1	13	83.00	5.31	70	89
2/1	3				

Table 12. Correlation between DLco and pulmonary parenchyma changes

ILO category	No. of patients	c	SD	Minimum %	Maximum %
0/1	45	79.3	7.28	60	90
1/0	19	78.16	7.30	70	90
1/1	13	74.85	6.35	60	80
2/1	3				

DLco = diffusion capacity for carbon monoxide; ILO = International Labour Organisation

The correlation between VC and degree of profusion of shadows in pulmonary parenchyma is shown in Table 11.

Duncan test was used to determine the difference in VC between group 2 and 3 patients.

The correlation of DLco and changes is shown in Table 12. Duncan test confirmed the absence of statistically significant difference between the groups.

Discussion

Pulmonary and/or pleural asbestosis is a chronic progressive pathology resulting from longtime inhalation of asbestos particles, most frequently at a workplace. The process is slow and permanently progressing as long as the person is exposed to asbestos. It ultimately causes severe cardiorespiratory problems and development of malignant

diseases (pleural mesothelioma, bronchial and peritoneal carcinoma). Since the clinical symptoms are atypical, the methods were sought for the detection of early forms of asbestos-induced disease.

The diagnosis of asbestosis is mainly based on chest x-rays in standard projections and oblique position performed by the so-called "hard" technique. In addition to confirmed asbestos exposure, another basic criterion for the diagnosis of asbestosis are radiologic changes in pulmonary parenchyma and pleura determined on chest film and coded according to the recommendations of ILO. Although the standardization of changes related to asbestosis through ILO classification from 1980 has considerably improved the diagnosis and follow-up of asbestosis-related changes, the method has numerous shortcomings.

The reasons are myriad: pathohistologic and morphologic characteristics of pulmonary/pleural asbestosis, patient's constitution, quality of radiologic technique, and radiologist's experience[8,9]. This particularly applies to the early stages of the disease.

The radiologic signs of pleural asbestosis are circumscribed pleural plaques (with/without calcifications), diffuse pleural thickenings (unilateral/bilateral) of different width and length, and pleural effusions. In our study, we found the diagnostic reliability of plain radiography and HRCT in detecting pleural plaques to be low. Similar results have been reported by other authors[10]. The more so, the sensitivity of plain radiography is not satisfactory because of quite a number of false negative findings[11].

Unreliable diagnosis is also caused by poor agreement between the radiologists reading the plain chest films[12].

Asbestosis is often accompanied by pleural calcifications. According to some authors, they are present in 20%-50% of cases[13-15]. In our study, the agreement of plain radiography and HRCT was pretty good regarding detection of pleural calcifications, and the same is reported by other authors[11].

In addition to the detection of pleural changes, especially pleural plaques, HRCT is particularly reliable in the follow-up of pleural change progression[16].

A non-specific interstitial pulmonary fibrosis occurs in pulmonary asbestosis. On x-ray, it is shown as an irregular net-like shadow mostly in the lower pulmonary regions[17]. Interpretation of these changes is one of the most common and most difficult problems in the diagnosis of lung disease[18]. Many authors report on a certain percentage of negative chest film findings in cases of pathohistologically confirmed asbestosis[17,19].

In our study, in 11 of 60 patients asbestosis was diagnosed only from HRCT scans. In 28 patients, it was not possible to diagnose asbestosis because of the variability of radiologist findings. The initial and moderate form of disease was diagnosed in 22 and six patients, respectively, which is consistent with literature data[20-23].

In the initial stages of disease, pulmonary functions are mostly within the normal values. The values begin to drop only when the changes are radiologically visible[24]. In our study, we found a statistically significant difference in VC value, which drops with the increase in pleural thickening. In parenchymal changes, a slight decrease in VC value was noticed with higher shadow profusion.

Diffusing capacity for carbon monoxide does not show any significant difference in different stages of the disease.

Conclusion

Clinical symptoms in patients with pulmonary/pleural asbestosis are not typical, particularly in the early stage of the disease, since they are similar to the symptoms of many other pulmonary diseases. The ILO classification is diagnostically not reliable enough. The reasons are both objective and subjective. The objective reasons include technical x-ray conditions, roentgen device, obesity and sex of patients, and pathomorphological characteristics of asbestosis. The subjective reasons include inexperienced radiologists and lack of agreement between radiologists about the findings.

The high-resolution computed tomography (HRCT) is the most sensitive method for the detection of early form of asbestosis, and it should be included in the examination algorithm for this disease.

Functional lung tests are much less significant for diagnosis accuracy because in the initial stage of the disease, the vital capacity (VC) and diffusing capacity for carbon monoxide (DLco) are within the normal values.

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Sažetak

DIJAGNOSTIČKA VRIJEDNOST KLINIČKIH, RADIOLOGIJSKIH I FUNKCIJSKIH PRETRAGA U BOLESNIKA S AZBESTOZOM PLUĆA I POREBRICE

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Cilj rada bio je utvrditi osjetljivost pojedinih radiologijskih i funkcijskih pretraga te njihovih odnosa kod ove bolesti. U radu je sudjelovalo 180 ispitanika oba spola. U svih su ispitanika učinjene standardne i kose snimke prsnoga koša tzv. "tvrdom" tehnikom snimanja. Kod 60 ispitanika učinjena je i visoko-rezolucijska kompjutorizirana tomografija. Od funkcijskih pretraga mjeren je vitalni kapacitet i difuzijski kapacitet za ugljični monoksid. Pleuralni plakovi su češći znak azbestoze pleure. U našem je istraživanju od 60 ispitanika rendgenogram prsiju ukazao na pleuralne plakove u 25 (41.6%), a visoko-rezolucijska kompjutorizirana tomografija u 51 (85%) ispitanika. Od 60 ispitanika s urednim nalazom rendgenograma prsiju (ILO 0/0 i 0/1) početna fibroza plućnog parenhima otkrivena je uz pomoć visoko-rezolucijske kompjutorizirane tomografije u 11 (18,4%) ispitanika. Zbog nepodudarnosti nalaza radiologa na konvencionalnoj radiografiji, u 28 od 60 ispitanika nije se mogla sa sigurnošću postaviti dijagnoza azbestoze. Visoko-rezolucijska kompjutorizirana tomografija je kod 22 (36,6%) ispitanika ukazala na početnu, a kod 6 (10%) na umjerenu fibrozu. Kod početnih oblika azbestoze vrijednosti vitalnog kapaciteta i difuzijskog kapaciteta za ugljični monoksid su u granicama normalnih vrijednosti. Tek veća prožetost sjena plućnoga parenhima i veća zahvaćenost zadebljanja pleure dovode do pada vitalnog kapaciteta.