Tanaffos (2004) 3(12), 35-42

HRCT in Early Diagnosis of Asbestos Related Pulmonary Disease

Mohammad Omid Tahbaz[1], Mohammad Ali Emam-Hadi [2], Mehrdad Nooraei [2], Mehrdad Bakhshayesh Karam[1], Soheila Zahiri-Fard[1], Abolhassan Halvani[3], Mohammad Reza Masjedi[3]

[1]Department of Radiology, [2] Department of Anatomical and Clinical Pathology, [3] Department of Pulmonary Medicine, NRITLD, Shaheed Beheshti University of Medical Sciences and Health Services, TEHRAN-IRAN.

ABSTRACT

Background: *In periodical occupational examination, for detection of pulmonary involvement, chest x-ray with ILO classification is used. This protocol is carried out on asbestos workers as well. However, chest x- ray is not valuable for early detection of asbestos related pulmonary changes.*

This study evaluated HRCT vs. chest x- ray in early detection of asbestos related pulmonary changes.

Materials and Methods: *This study was performed in November 2002 among "Hajat Chrysotile Asbestos Factory" and mine workers located in Nehbandan-Birjand, Khorasan province.*

A total of 49 asbestos mine workers with minimal respiratory symptoms were chosen. The level of asbestos in different areas of the factory and mine was measured. All workers were interviewed and underwent clinical examination, chest x-ray and HRCT.

Results: *The mean value of asbestos in the respiratory field of asbestos exposed workers was about 80 times over the standard limits (39.75 f/ml; TLV= 0.5 f/ml). On chest x-ray based on ILO classification, 3 individuals (6.1%) showed reticulonodular involvement. The most common intensity of involvement was generally I/I in bases of the lungs. HRCT findings demonstrated pulmonary parenchymal involvement in 32 cases (65.3%). In 29 cases, there was no abnormality in chest x-Ray, while it was present in HRCT. In 17 cases both tests were negative. There was no positive chest x-ray in HRCT negative cases. Sensitivity of chest x-ray was 9.5% and specificity was 100%.*

Conclusion: *According to sensitivity, use of chest x-ray as a diagnostic test for evaluation of asbestos related pulmonary diseases does not have enough value for detection of patients. Therefore, in the evaluation of occupational disorders and law suits (in those cases with the most simple sign and symptoms), HRCT should be performed.* ***(Tanaffos 2004; 3(12): 35-42)***

Key words: *Asbestos, Asbestosis, Asbestos related pulmonary diseases, CXR, HRCT, Sensitivity, Specificity*

INTRODUCTION

Asbestos is an ancient term, and in geology is defined as a group of organic compounds with hydrated magnesium silicate as elastic fibers with resilient structure (1,2).

This mineral is divided into two main groups according to its physical and chemical characteristics: Amphiboles and serpentine. Each one has its own specific characteristics (1, 2, 3).

As a result of unique physical and chemical

Correspondence to: emam-Hadi MA
Tel:+98-2122803550, Fax:098-21-22285777
Email address: emamhadi@yahoo.com

characteristics, asbestos is widely used in different army industries, rocket construction, ship construction, automobile factories, thermal industries, insulation, construction, pipe making industries, roof tiles, and break lining etc.

Till 1970, asbestos was used in about 3000 different products, but nowadays it is widely decreased to about 200 commercial products due to its limitation (4,5).

Asbestos is one of the most important factors in causing occupational diseases (6, 7).

However, noting the important physical and chemical characteristics and not finding an appropriate replacement for it, scientists started to perform extensive researches on its different types. They finally stated that some kinds of asbestos especially chrysotile (white), have negligible complications as compared to other types of asbestos (8, 9, 10).

Consequently, use of amphiboles was prohibited all over the world in spite of its great physical and chemical characteristics (10). The threshold limit value of asbestos fibers has been changed by the researchers during the years. At the present time, the threshold limit value (TLV) of asbestos is 0.1 f/ml (Fiber per Millilitre) for amphibole and 0.5 f/ml for chrysotile (11).

Despite the numerous protective preparations, asbestos is still a hygienic hazard in the world. Nowadays, industries, factories and mine workers are examined periodically to prevent from occupational diseases. In asbestos workers, periodical clinical examinations are performed every 6 months including chest x-ray and spirometry in case of presence of clinical signs. This study aims to evaluate this recommended protocol by performing HRCT(High Resolution Computerized Tomography).

Since management of asbestos related pulmonary complications is difficult and mostly impossible, it is better to diagnose pulmonary changes at early stages by special means; in this way, the irreversible pulmonary changes, mortality and morbidity of the workers can be prevented.

MATERIALS AND METHODS

The Hajat mine and factory are located at a distance of 200 kms from Mashad and 35 kms of east of Birjand.

The type of extracted asbestos is chrysotile (white asbestos). The tonnage of the factory is a maximum of 2 tons, per month. The mine is exposed and mine stone is extracted by the loader and is carried to the factory by the truck.

The distance between the mine and the factory is about a kilometer. The factory has lines of stone crushing, transportation, distinguishing, separation, packing, and loading. Total number of the workers is 105 persons; from those 80 individuals are working in production field.

Unfortunately, none of the mine and factory workers use standard (filtered) masks. Some workers do not use masks, some use paper masks or a piece of cloth as a mask.

Methodology:

This was a cross-sectional study. At the first stage, a history was obtained from all patients and all were examined clinically. Later, by measuring the asbestos doses in the respiratory field of asbestos exposed workers in different parts of the mine and factory, 7 zones were selected according to the intensity of contamination.

Out of 80 workers in direct contact with asbestos, 53 had minimal respiratory symptoms. From those, 4 were excluded due to their lack of cooperation. Finally, 49 workers were evaluated. Patients were in the age range of 34-49 years with mean age of 42-46 years and occupational history records of 13-15 years.

Understudy workers were taken to Farabi Hospital in Mashad. They filled out the questionnaire and the consent, and underwent clinical examinations, chest x-ray and HRCT. The results were descriptively analyzed and comparative, sensitivity and specificity tests were performed.

Method of evaluation:

Method of measuring the values of asbestos in the respiratory field of workers:

According to the ASTM (American Society for Testing and Materials) (12, 13) statement, a 37-mm cellulose filters with 0.8 micron pores were used in all individual samplings. The filter holder was open face in samplings, and a protective plastic cowl was used over the holders to reduce the possibility of incidental filter contamination as well as destroying the electrostatic effects.

The individual sampling pump was diaphragmatic type with the dimensions of 4(7.8) × 3(1.2) × 2(1.2). The microscope was Zeis equipped with contrast system and magnification of 500 × 125.

In counting the fibers the Wallton-Backett calibre graticoles with the standard length in diameter ratio and to vaporize the samples the acetone vaporizer apparatus made in SKC Factory by use of some microlitres of acetone and immersion oil with the refraction co-efficiency of 1.510 was used.

In evaluation of the rate of workers' exposure to asbestos fibers, we did our best to sample the air from every place which had the possibility of asbestos contamination. While considering the condition of the sampling environment, 40 fibers in 100 graticole field was considered as the minimum load of the fiber. Meanwhile, 300 fibers in 100 graticole field were regarded as maximum load of the fiber. We took three samples from each zone of the mine and factory in order to choose samples with best quality and quantity.

All cases underwent expiratory HRCT by a General Electric CT-scan with similar protocol of:

Time: 0.8Sec, MA: 200, KV= 120 chest standard reconstruction matrix= 512, slice thickens= 1 mm. High speed (Fxi); Image interval= 15 mm.

After CT, radiograms were interpreted by three radiologists separately and later together.

HRCT findings were recorded for each person according to the questionnaire criteria.

RESULTS

Epidemiologic findings:

Test results showed that the only asbestos in this mine was chrysotile type (white asbestos) and no amphibole asbestos was seen as a pure or gross.

The asbestos value in the exposure range of workers was measured by two different centers with a 2-year interval.

The results indicated very high rate of contamination (more than 100 times over the safe limit) in some parts of the factory (table 1).

Table 1. Measurement of the asbestos value in respiratory field of seven different parts of the factory and mine.

Average	39.754
Mean	41.4
Standard deviation	15.449
Variance	238.6925
Range of variations	55.33
Minimum	10.67
Maximum	62

Chest x-ray results:

Out of 49 cases, 3 (6.1%) showed pulmonary parenchymal involvement as reticulonodular pattern according to ILO classification. The most common intensity rate of involvement was in I/I and the most common form according to IL0 classification was P/p (table 2).

The most common site of involvement was at the lung bases and with less prevalence in upper and middle zones.

Table 2. Incidence rate of pulmonary radiological manifestations due to chrysotile asbestos (HRCT and chest x- ray) in workers in contact with asbestos.

Parenchymal involvement	Frequency	Percentage
Pulmonary radiological manifestations (HRCT)	32	65.3
Pulmonary radiological manifestations (CXR)	3	6.1

HRCT results:

HRCT findings confirmed the pulmonary parenchymal involvement in 32 persons (65.3%) as different types of septal thickening, ground glass opacity, linear density, subpleural curvilinear lines or band, and parenchymal band (table 2). Comparing chest x-ray and HRCT findings, in 3 cases both tests (HRCT and chest x-ray) showed parenchymal involvement. In 29 cases with positive HRCT, no involvement was seen in chest x- ray. In 17 cases out of 49 persons, both tests were negative.

In none of the HRCT negative cases, chest x- ray was positive (table 3).

Table 3. Evaluation of the sensitivity and specificity rates of HRCT and chest x-ray tests.

		HRCT	
		+	-
C.X.Ray	+	3	0
	-	29	17

Sensitivity= 9.5% & Specificity= 100%

Also, there was a significant difference between the pulmonary parenchymal involvement of the workers of different parts of the mine and factory and the level of asbestos in the air ($p < 0.01$) (table 4).

Table 4. Correlation between the asbestos value and parenchymal lesions seen in HRCT.

		Asbestos value	HRCT
Asbestos value	Pierson's correlation	1	0.850
	2 variables significance	0	0.001
	Number	49	49
HRCT	Pierson's correlation	0.850	1
	2 variables significance	0.001	0
	Number	49	49

The radiologists' agreement in interpreting the HRCT was more than in chest x-ray (86% versus 58%).

DISCUSSION

Asbestos is one of the most important factors in causing occupational diseases. Numerous clinical and epidemiological findings have demonstrated that this material can cause numerous diseases in various body organs such as skin (asbestos blisters), lung (asbestosis or diffused pulmonary fibrosis, cancer, mesothelioma, pleural effusion, benign pleural plaques), probably gastrointestinal cancer, carcinoma of the larynx and thyroid as well as nervous system disorders (1, 2, 3).

Asbestos related diseases usually appear 15 to 40 years after first contact with asbestos fibers, and depend on various factors such as type and characteristics of the asbestos fibers, duration of the contact, rate of exposure, residence in susceptible areas etc. (6, 7).

In this study with the average occupational history of about 13 years, there were considerable pulmonary lesions in some workers. Some of these workers have been in contact with asbestos in a rate of one hundred and twenty times over the safe limit.

Presence of considerable pulmonary lesions in workers with such occupational history shows that with increased rates of asbestos value in the respiratory field of a worker, manifestation of the pulmonary lesions will occur earlier than the expected time.

The relation between the severity of lesion and high rate of exposure has been proved in regard to amphiboles (14), while it is controversial in regard to chrysotile.

In a study, researchers did not found any relation in this regard about chrysotile in workers of Eastern London factory (15). On the other hand, these researchers noted this relation in workers of the chrysotile asbestos products factory (16).

This was also demonstrated by other researchers in chrysotile mines of Quebec. Results of this study show that chrysotile asbestos is not only dangerous but there is also a significant correlation between the lesions and the rate of asbestos in the respiratory field of workers. On the other hand, it is demonstrated that marked pulmonary lesions can appear in shorter period and less than expected time in case of high level of contamination (17).

Hajat mine was discovered by an English-Indian company and its production line was put to work experimentally.

Since the factory was still at experimental state it did not have the capacity to produce the expected volume which is producing now (According to TLV= 0.5 f/ml contamination more than 100 times over the safe limit in some parts of the factory). On the other hand, presence of seasonal 120-day winds of Sistan area has caused the asbestos fibers to get scattered on a field as wide as more than 15 kilometers from the mine.

Presence of HRCT findings in a considerable number of Hajat mine workers shows the serious risks of chrysotile asbestos.

Asbestosis is one of the most common and serious pulmonary complications caused by asbestos.

Asbestosis is defined as diffuse pulmonary interstitial fibrosis due to asbestos fiber inhalation and is one of the most important lung diseases (1, 2, 3).

Although intensive control of asbestos use cause decreased prevalence of asbestosis (8) but by passing time and as a result of the long latent period of asbestosis manifestation (15-40 years) new patients are still diagnosed and referred to be treated (1, 2, 3).

Epidemiologic studies indicate that above the standard dose of asbestos is needed to result in asbestosis (25-100 f/ml/y) (7,18). Therefore, asbestosis is mostly seen in workers with a history of long term contact with asbestos such as mine, insulation, and asbestos products workers. Workers of the Hajat asbestos mine have been in contact with asbestos with an exposure of about 100 times greater than the safe limit. Therefore, manifestation of asbestosis is expected in them.

If no history of occupational contact is available, clinical, physiological and radiological findings of asbestosis are similar to the diffuse pulmonary interstitial fibrosis especially interstitial pneumonitis and ILD.

Definite diagnosis of asbestosis is based on the pathological findings and presence of asbestos body.

Asbestos body in fact is asbestos fiber covered by protein and inflammatory cells. However, it is not always possible to perform sampling and pathological evaluations.

Hence, study of the clinical and paraclinical signs such as chest x-ray and respiratory tests can be very helpful.

Chest x-ray findings are usually observed as reticulonodular infiltration, and are mainly presented in the lower segments of the lung (19).

It is said that HRCT has a greater value in diagnosing various types of pneumoconiosis (20).

HRCT findings are various and consist of inter and intralobular lines, specially in the bases of the lung, honey comb, subpleural nodules or lines

(20,21,22), parenchymal band, interstitial lines (20) architectural distortion, and calcification (22).

Presence of pleural plaques is helpful in diagnosis (23). In evaluating 49 workers from the asbestos Hajat mine with minimal respiratory symptoms which were considered as healthy persons, chest x-ray showed reticulonodular pattern in 3 cases (6.1%). In HRCT, pulmonary parenchymal involvement in 32 persons (65.3%) was observed in different forms such as: parenchymal band, septal thickening, ground glass opacity, linear density, subpleural curvilinear lines or band.

In regard to sensitivity and specificity analysis, the sensitivity rate of chest x-ray compared to HRCT was 9.5% and its specificity was 100%.

Considering the above mentioned sensitivity rate, chest x-ray as a diagnostic mean does not have the ability to recognize the asymptomatic patients.

In routine examination of the workers, at first clinical examination and paraclinical tests were performed to evaluate the involvement of liver, kidneys and hematopoetic system etc (according to the type of contaminator of the working place). Chest x-ray and some other tests such as audiometry, spirometry etc. are also used when appropriate.

Then, according to the level of contamination of the working place a 6-month or annually periodical examinations are performed. In regard to asbestos 6-months periodical examination is completed by obtaining spirometry and chest x-ray if needed.

As mentioned before, chest x-ray could never help in diagnosing the complications observed in the initial stage of the disease.

Therefore, it is recommended to obtain HRCT as a complementary test or the only diagnostic test in this group of persons who are in contact with asbestos.

CONCLUSION

This study indicated that in high levels of chrysotile asbestos, pulmonary lesions will appear in less than the expected time. (On average 13 years versus 15-40 years). We also showed that chest x-ray has a limited diagnostic value as compared to HRCT.

Noting these factors is very important in asbestos workers, because there are always some occupational problems and lawsuits about these workers.

Therefore, it is recommended to use HRCT as a diagnostic mean during some of the periodical examinations specially when the workers suffer from respiratory symptoms even mild ones, or when they have some lawsuits.

Acknowledgement

We would like to thank NRITLD, asbestos corporation (Mr. Lameaei Eng.), Hajat asbestos mine and factory (Mr. Gholizadeh Eng.), Birjand University of Medical Sciences and Health Services (Dr. Shakibi, Dr. Zarban), Birjand Valiasr Hospital (Dr. Ganji), Mashad Farabi Hospital, Mrs. Natagh, Mrs. Roohi, Mr. Hassan Nickpay, Mrs. Melody Nekoorooh and others who helped us in performing this research and preparing this article.

REFERENCES

1. Veblen DR, Wylie A G. Mineralogy of amphiboles and 1:1 layer silicates. In G.D. Guthrie, Jr and B.T. Mossman, editors. Health Effects of Mineral Dusts. Reviews in Mineralogy. 1993 Vol 28. Washington, DC Mineralogical Society of America. 61-138.
2. Jaurand MC, Gaudichet A, Halpern S, Bignon J. in vitro biodegradation of chrysotile fibres by alveolar macrophages and mesothelial cells in culture: comparison with a pH effect. ***Br J Ind Med*** 1984; 41(3): 389-95.
3. Hardy JA, Aust A E. Iron in asbestos chemistry and carcinogenicity. Chem 2000; 95: 97-118.
4. Hume L.A, Rimstidt J D.The biodurability of chrysotile asbestos. ***Am Mineral***. 77: 1125-28.
5. Light WG, Wei ET. Surface charge and asbestos toxicity.

Nature 1977; 265 (5594): 537-9.

6. Churg A. Deposition and clearance of chrysotile asbestos. ***Ann Occup Hyg*** 1994; 38 (4): 625-33, 424-5.
7. Coin PG, Roggli VL, Brody AR.Deposition, clearance, and translocation of chrysotile asbestos from peripheral and central regions of the rat lung. ***Environ Res*** 1992; 58(1): 97-116.
8. Adamson IY, Bowden DH. Response of mouse lung to crocidolite asbestos. 2. pulmonary fibrosis after long fibres. ***J Pathol*** 1987; 152(2): 109-17.
9. Davis JM, Addison J, Bolton RE, Donaldson K, Jones AD, Smith T. The pathogenicity of long versus short fiber samples of amosite asbestos administered to rats by inhalation and intraperitoneal injection. ***Br J Exp Pathol*** 1986; 67(3): 415-30.
10. Platek SF, Groth DH, Ulrich CE, Stettler LE, Finnell MS, Stoll M. Chronic inhalation of short asbestos fibers. ***Fundam Apple Toxicol*** 1985; 5(2): 327-40.
11. Sabourin CR, Flinn BD, Pitts DL, Gatten TL, Johnson JD. 2004. Standard Practice for Asbestos Detection Limit Based on Counts. American Society For Testing and Materials (ASTM) publications, Philadelphia, PA.; Volume: 11.03; Section 5. 455-6
12. American society for testing and materials. Standard test method for microvacuum sampling and indirect analysis of dust by transmission electron microscopy for asbestos structure number surface loading. Annual Book of ASTM Standards. American Society for testing and materials. 2004. Philadelphia, PA. Volume: 11.03; Section 4. 437-8.
13. Beard JD. Rook A. Advancements in Environmental Measurement Methods for asbestos.1999. Vol 4; 425.
14. Churg, A., and B. Stevens. 2003. Enhanced retention of asbestos fibers in the airways of human smokers. Am. ***J. Respir. Crit. Care Med***. 151: 1409-13.
15. Browne, K. 1994. Asbestos-related disorders. In W. R. Parkes, editor. Occupational Lung Disorders, 3rd ed. Butterworth-Heinemann, Ltd., Oxford. 411-504.
16. Gibbs AR, Pooley FD. Analysis and interpretation of inorganic mineral particles in “lung” tissues. ***Thorax*** 1996; 51(3): 327-34.
17. Churg A, Wright JL, Vedal S. Fiber burden and patterns of asbestos- related disease in chrysotile miners and millers. ***Am Rev Respir Dis*** 1993; 148(1): 25-31.
18. Churg A, Wright J, Wiggs B, Depaoli L. Mineralogic parameters related to amosite asbestos-induced fibrosis in humans. ***Am Rev Respir Dis*** 1990; 142(6 Pt 1): 1331-6.
19. Akira M. High-resolution CT in the evaluation of occupational and environmental disease. ***Radiol Clin North Am*** 2002; 40(1): 43-59.
20. Hartley PG, Galvin JR, Hunninghake GW, Merchant JA, Yagla SJ, Speakman SB, et al. High- rsolution CT-derived measured of lung density are valid indexes of interstitial lung disease. ***J Apple Physiol*** 1994; 76(1): 271-7.
21. Herman M, Kolek V. Diffuse interstitial lung disease—evaluation with high-resolution computed tomography. ***Acta Univ Palacki Olomuc Fac Med*** 1993; 135:25-30.
22. Huuskonen O, Kivisaari L, Zitting A, Taskinen K, Tossavainen A, Vehmas T. High-resolution computed tomography classification of lung fibrosis for patients with asbestos-related disease. ***Scand J Work Environ Health*** 2001; 27(2): 106-12.
23. Oksa P, Suoranta H, Koskinen H, Zitting A, Nordman H. High-resolution computed tomography in the early detection of asbestosis. ***Int Arch Occup Environ Health*** 1994; 65(5): 299-304.