

PULMONARY FUNCTION TESTS AND CHEST X-RAY FINDINGS IN COAL-MINE WORKERS WITH RESPIRATORY SYMPTOMS

Mukhtiar Zaman, Saadia Ashraf*, Amber Ashraf**.*

ABSTRACT

Objective: To detect presence of Coal-workers Pneumoconiosis (CWP) in the symptomatic coal miners and to document their lung function and chest X-ray findings.

Design: An observational study of randomly selected coal-mine workers from district Shangla who had respiratory symptoms.

Place and Duration of Study: Cenna Medical Centre, Swat in June 2003.

Patients and Methods: Study sample of 101 male participants were administered a questionnaire to know their demographics, occupational history, symptoms followed by clinical examination, pulmonary function tests and chest x-rays.

Results: The mean age group of the study sample was 37.56 yrs and BMI of 20.3. The mean of, starting work age was 17 yrs; duration of work 13 yrs and work per day was 9.57 hrs. 94 out of 101 had used or using tobacco in one or the other form; 18 smoked cigarettes, 67 used snuff and 4 used both. 95 out of 101 participants experienced dyspnoea; 5,38,24,28 experienced activity grade 1,2,3,4 dyspnoea respectively. The mean percent predicted FEV1, FVC, PEFR was 77, 67, 94 and FEV1/FVC was 104%. The chest x-rays were read and classified according to 1980 ILO international protocol. 4, 28 and 73 chest X-rays revealed respectively normal, complicated CWP and simple CWP, with profusion abnormalities of 0/1 to 3/+ categories.

Conclusion: This study confirms the presence of Coal Workers Pneumoconiosis in previously undiagnosed symptomatic coal-mine workers of variable severity. We recommend that for present and ex coal-miners a regular surveillance programmes should be organized.

KEY WORDS: Coal workers Pneumoconiosis, Symptoms, Chest X-rays. * Department of Pulmonology, Khyber Teaching Hospital, Peshawar.

INTRODUCTION

Coal has been the most frequently and widely used mineral for centuries but at the same time respiratory diseases and disabilities related to occupational exposure to this dust has been the most commonly recognized in both developed and developing countries¹. Coal is still a significant source of energy and is mined in many countries including Pakistan. Pakistan has got extensive coal deposits, 184 Billion tones², in all the four provinces, including NWFP. Cherat and Hangu are the main areas in NWFP, renowned for coal mining and the estimated reserves only in Cherat area is of 2 million tons and the type of the coal is bituminous³.

Coal miners are at risk of developing several diseases related to their occupational dust exposure, depending upon the type and nature of the dust, size of the inhaled particles, age at first exposure, total duration of exposure and nature of the job^{4,5}.

** Department of Cardiology, Khyber Teaching Hospital, Peshawar.

Unlike the developed world where the prevalence of Coal workers Pneumoconiosis (term generally applied to interstitial disease of the lung resulting from chronic exposure to coal dust, its inhalation and deposition, and the tissue reaction of the host to its presence⁶) is on the decline because of enforcement of effective measures to maintain coal workers exposure to respirable dust at or below $2\text{mg}/\text{m}^3$.^{5,6,7,8}, the situation in Pakistan is unclear because of lack of data and monitoring system. During the period 1950-80, the annual UK rate for recognition of CWP in current and retired miners for state compensation decreased from about 7% to 1-2%. The overall prevalence of CWP, which reflects more distant exposure and earlier incidence, declined from about 13% to 5% but there were substantial regional differences.⁸ In USA, during the period 1970-1995, the prevalence of CWP in active US miners decline from 28- less than 10% due to enforcement of compliance with dust control measures^{9, 10, 11}. In countries like Vietnam, the official statistics underestimate the situation because of the inadequacy of the reporting system¹².

Pneumoconiosis is still a major cause of disability worldwide despite a decreasing incidence in western countries¹¹ and Pakistan is no exception though the burden of the disease is unknown.

Recognition is the first step towards control of any hazard though linkage with effective surveillance programs and competent prevention efforts is paramount¹⁴.

We conducted this study with objectives

- To detect any presence of Coal workers Pneumoconiosis (CWP) in the symptomatic coalminers
- To document their Lung Function and chest x-ray findings.
- To grade the severity of dyspnoea

PATIENTS AND METHODS

This observational study was conducted in June 2003 at Cenna Medical Centre Swat. Purposive non- probability multi stage sampling technique was employed to conduct the study from Shangla District because of the common knowledge that majority of miners working in the coal mines in NWFP are inhabitants of that district.

All symptomatic coal mine workers, who were male and worked for at least one year in the coal mines, were eligible for the study whereas those who were too ill to travel or had concomitant overt cardiovascular disorders, neuromuscular dysfunction and malignant disease at the time of study were excluded .

After informed verbal consent, the study population were interviewed by trained research assistants to obtain their demographic details, occupational, and smoking histories, using a structured questionnaire. This was followed by medical examination, Spirometry and Chest x-rays (PA view).

Spirometry was performed by expert technician. Each subject performed at least three acceptable spirograms. The best curve with the largest FVC and FEV_1 --- was selected for analysis, and FEV_1/FVC was calculated. Chest X- rays were read by 2 experts using 1980 ILO radiological classification ^{4, 5}.

RESULTS

107 symptomatic coal miners were interviewed and data of 101 were further analysed after excluding data of 6 participants because of not fulfilling the inclusion criteria, using a statistical software.

The demographic details of the study sample are given in table 1. The mean body mass index of the study sample is towards low normal. Coal workers start working at coal mines at very young age and the mean duration of work in coal mines among the study sample is 13 years. Mostly are married and has to look after a large family with an average family of 10. Despite working for 10 hours per day, 68% reported to have monthly income of less than Rs.5,000. Most of the workers have used tobacco in one form or the other, though cigarette smokers are only 19 %.

Major jobs of the miners were underground coal cutting, drilling and coal transportation. (Table 2). Shortness of Breath (Dyspnoea) was experienced by 95% of the participants and other reported symptoms and their frequencies are shown in table 3. Participants experiencing dyspnoea on running, walking uphill, walking flat and while offering prayers was graded as 1, 2, 3 & 4 and number with percentages are shown in table 4. Despite complaining of respiratory symptoms, wasting was observed in 19 participants and only 48 had some abnormal finding during chest examination (table 5).

Pulmonary Function Tests clearly revealed more reduced percent predicted FVC than FEV₁ and FEV₁ / FVC ratio was more than 104, indicating restrictive pattern whereas PEF_R was preserved. (Table 6, the values of Pulmonary Function, except FEV₁/FVC, are expressed as percent predicted.)

Sample size	N=101
Mean age of study sample	38 yrs(20-75)
BMI	20.3kg/m ²
Mean age at starting work	17 yrs (9- 27)
Married	90 (89%)
Educated	44 (43%)
Average duration of work	13yrs (1yr- 44yr)
Average hours of work/ day	10 (7-12)
Average Family size	10
Tobacco used (N=101) Yes	94 (93%)
No	7 (7%)
Tobacco used (Yes)	N=94
Current User	52 (55%)
Ex- User	42 (45%)
Kind of Tobacco used	N=94
cigarette	18 (19%)
snuff	67 (71%)
others	09 (10%)
Monthly household income	N= 101
Less than 5000	68 (67%)
5001- 10,000	27 (26.7%)
More than 10,000	06 (5.9%)

TABLE 2 JOB NATURE

Job nature	N=101
Cutting	47 (46.5%)
Drilling	14 (14%)
Labourer	30 (29.5%)
Others	10 (10%)

TABLE 3 SYMPTOMS & SIGNS

SYMPTOMS	No.	(%)
Shortness Of Breath	95	(95)
Weight Loss	78	(78)
Cough	82	(82)
Chest Pain	84	(84)
Fever	49	(49)
Feeling of ill health	87	(87)

TABLE 3 SYMPTOMS & SIGNS

SYMPTOMS	No.	(%)
Shortness Of Breath	95	(95)
Weight Loss	78	(78)
Cough	82	(82)
Chest Pain	84	(84)
Fever	49	(49)

TABLE 4

Dyspnoic on	N0. (%age)
1= Running	5 (5.26)
2=Walking up hill	38 (40)
3=Walking on flat	23 (25.3)
4=Offering prayers	29 (29.4)

TABLE 5 PHYSICAL EXAMINATION

General Physical Exam	Number	%age
Skeletal Abnormality	3	2.97
Wasting	19	18.83
Clubbing	2	1.98
Pigmentation	5	4.95
Oedema Feet	3	2.97
Chest Exam Abnormal	48	47.85

TABLE 6 PULMONARY FUNCTION TESTS

	PREDICTED(mean) L/S	P E R C E N T	
OBSERVED(mean) L/S	PREDICTED		
FEV ₁	3.57	2.73	77
FVC	4.3	2.89	67
FEV ₁ /FVC			104
PEFR	515	485	94

TABLE 7 RADIOGRAPHIC CLASSIFICATION

Profusion Category (small opacity)	Total No	Percentage%
0	26	25.74
1	30	29.70
2	24	23.76
3	21	20.79
Total	101	100%

Category 1 and above pneumoconiosis was evident in the Chest X-rays in 74.5% symptomatic coal workers. (table7) Large opacities indicating Progressive Massive Fibrosis (PMF) was present in 28 workers (table 8).

Table 8 shows the Chest X-ray findings in relation to the grade of dyspnoea. There is corresponding increase in the profusion abnormalities and presence of large opacities in the x-rays of the participants with increasing grades of dyspnoea.

TABLE 8 RELATIONSHIP OF SEVERITY OF DYSPNOEA WITH CHEST X-RAY FINDINGS

Shortness of Breath (Grades)	Number Of Patients (n = 95)	X-Ray Findings										
		Small Opacity						Large Opacity				
		Profusion		Extent		Size		Present		Size		
		1	2	<3	>3	p	non-p	No	Yes (N=28)	A	B	C
1	5	5	0	4	1	3	2	4	1	1	0	0
2	38	26	12	19	19	32	6	30	8	3	3	2
3	23	10	13	7	16	8	15	16	7	4	1	2
4	29	12	17	13	16	27	2	17	12	9	1	2

DISCUSSION

The prolonged inhalation of coal-mine dust may result in the development of three conditions: Coal- workers pneumoconiosis (CWP), Silicosis and industrial chronic bronchitis and emphysema⁵. The pathogenesis of CWP is unclear. CWP is classified into two categories according to radiographic appearance: simple and complicated. Complicated pneumoconiosis is recognized as a more advanced disease and is also called progressive massive fibrosis¹⁵. A major survey of the health of American Coal workers was conducted by the US Public Health Service (USPHS) from 1969-1971, showing an overall prevalence of simple and complicated pneumoconiosis of nearly 30%^{16,17}. In our sample of 101, there are 75 participants with category 1 or more radiological changes of pneumoconiosis. The higher percentage in our data can be explained by small sample size of symptomatic coal miners instead of being epidemiological survey of all miners.

Xiarong Wang¹⁸ reported that younger age at first employment heighten the potential for increased risk of clinically significant CWP and 25years or more of underground mine work results in 28 percent of prevalence of CWP^{4, 9, 17}. In our study the mean age of starting work at mines is 17 years (9-27) and mean duration of work is 13 years. (the total duration of work is self reported and is subjected to recall and there is no objective way of confirming it). The younger age employment

among the study sample could be explained on the basis of low socio-economic status; 67% of participants has monthly house hold income of less than Rs.5000, low literacy rate; 56.4% are illiterate, and large family size; 10 members per family. In this study though the mean duration of work is only 13 years but the high percentage of pneumoconiosis in the sample could be explained by the underage work, high accumulated dose and probably other unknown compounding factors.

Lynn⁴ and Hurley¹⁹ suggested that by avoiding further exposure to coal dust of miners with radiological changes of category 1 or less, the progression to complicated form of CWP-progressive massive fibrosis(PMF) can be prevented but this is not the case in the miners with category 2 pneumoconiosis, where the probability of its progressing to the complicated form appears to be independent of any further dust exposure. The rate of progression to PMF appears to be influenced chiefly by the age at which the miner begins to show radiographic changes of CWP.⁴ In our study majority of the participants has got simple CWP and PMF and there is no health care provision either from the government or the coal industry. The patients with category 2 and above may end up with PMF and death, as it is well known that approximately 4% of coal workers death is directly attributable to pneumoconiosis, usually PMF^{20,21}.

Smoking is recognized as a major risk factor for respiratory impairment among dust exposed workers²². Ninety three percent of our sample is either current or ex tobacco users but only 19% are smokers and the rest are snuff users. There is no national or international studies available, showing effect of snuff on lung functions either in coal miners or normal population.

Not all coal mining jobs are equally exposed to respiratory hazards^{23, 24, 25, 26,27} mechanics, electricians, and maintenance men have the least amount of dust exposure compared to drilling, cutting and transportation²³. In our study the participants jobs and mines had changed frequently, making it difficult to define specific job for each participant or correlate one mine and coal quality with the frequency of CWP. The major jobs of the study participants were cutting, drilling and transportation. Such high risk jobs may be another explanation for the high frequency of pneumoconiosis in our sample.

Dyspnoea was experienced by 95 workers and it is in agreement with international studies in which dyspnoea is the most commonly reported symptom^{5,22, 28,29}. Henneberger³⁰ and Xiarong Wang¹⁸ suggested that respiratory symptoms might provide an early warning of subsequent functional decline. In our study the lung functions of the participants were reduced and FEV1/FVC ratio is indicative of restrictive pattern. The restrictive pattern may be explained by the high number of, 27.75%, cases of PMF in this study.

Whether functional abnormalities and respiratory symptoms can reflect the extent of pathological and radiological pneumoconiosis has been an issue of concern for both clinical practice and scientific research. It is not surprising to find conflicting results in literature. This is attributable to the wide variety of clinical and pathologic forms of coal-related diseases. For CWP, although some studies commonly observed severe respiratory impairments in complicated disease^{5,31, 32,33}, neither degree of impairment nor occurrence of symptoms has correlated well with the extent of chest radiographic abnormalities^{29,34,35}. This study clearly shows that the degree of dyspnoea is closely related to the radiographic severity of pneumoconiosis. This finding is consistent with other studies^{19,22,27,32}.

CONCLUSION

This study confirms the presence of Pneumoconiosis in symptomatic coal- mine workers and radiographic evidence of pneumoconiosis, thus highlighting the need for regular surveillance programme among coal-mine workers. To conduct well planned epidemiological studies in order to clarify the actual condition of pneumoconiosis among coal mine workers and to implement effective counter measures for prevention.

REFERENCES

1. Banks D. The worldwide problem occupational lung disease. In: Banks DE, Parker JE, eds. Occupational Lung Disease: An International Perspective. London: Chapman & Hall Medical; 1999: 3- 16
2. Ahmad N and Ahmad Z.S. Preliminary Report On Coal Occurrences in NWFP. Sarhad Development Authority Report. 1995
3. Khan Gul Jadoon, Noor Muhammad, Siddique Akbar. Design and Safety improvement of underground coal mines in Cherat area. NWFP. Dec 2001
4. Lynn T.Tanoue. Coal workers lung diseases and Silicosis. Fishmann's manual of respiratory diseases.3rd edition: 238-249.
5. W.Raymond Parkes. Pneumoconiosis associated with coal and other carbonaceous materials. Chapter 13 .In: Occupatonal Lung Disorders by W. Raymond Parkes 3rd ed: 349-410.
6. William G Hughson. Coal workers pneumoconiosis. Manual of clinical problems in pulmonary medicine. fifth edition. chapter 80, page 421-424..
7. Haselton PS: Spencer's Pathology of the Lung. 5th ed. McGraw-Hill; 1996:475-483.
8. Benoit Wallaert Based on chapter by WKC Morgan. Respiratory disease in Coal miners.chapter 26. page 693-706.
9. CDC/NIOSH: Criteria for a recommended standard. Occupational Exposure to Respirable Coal Mine Dust. DDHS (NIOSH) Publication No. 95- 106. September 1995.
10. Attfield MD, Sexias NS: Prevalence of pneumoconiosis and its relationship to dust exposure in a cohort of US bituminous coal miners and ex-miners. Am J Ind Med 27: 137- 151. 1995.
11. Jacobsen M, Rae S, Walton WH, Rogan JM: The relation between pneumoconiosis and dust exposure in British Coal mines, in Walton WH(ed), Inhaled particles Vol 111. Woking, Surrey, Unwin Brothers, 1971. pp 903-917.
12. Nguyen An Luong, Shinya Matsuda. Pneumoconiosis problem among the Vietnamese Coal mine workers. JUOE 1998. 20 (4): 353-360.
13. American thoracic society. Adverse effects of crystalline silics exposure. Am J' Respir Crit Care Med 1997; 155: 761-8.
14. Le Van Trung, Nguyen Thi Hong Tu, Scot Barnhart. Pneumoconiosis Prevention Programme in Vietnam, Mineral dusts and prevention of silicosis, September 1997 vol 4; No.2.
15. UICC Committee.1970. UICC/ Cincinnati classification of roentgenogram appearance of pneumoconiosis. Chest 58: 57-67.
16. Morgan WKC, Burgess DB, Jacobsen G et al: The prevalence of coal workers pneumoconiosis in US coal miners. Arch Environ Health 27: 221-226.1973.
17. Rom WN, Kanner RE, Renzetti AD Jr, Shigeoka JW, Barkman HW, Nicols M et al. Respiratory disease in Utah coal miners. Am Rev Respir Dis. 1981 Apr; 123: 372-7.
18. Xiarong Wang, Ignatius T.S.Yu, Tze Wai Wong and Eiji Yano. Respiratory Symptoms and Pulmonary Function in Coal Miners: Looking into the effects of Simple Pneumoconiosis. Am J Ind Med 35: 124- 131 . 1999.

19. Hurley Jf, Alexander WP, Hazledine DJ, Jacobsen M, Maclaren WM. Exposure to respirable coal mine dust and incidence of progressive massive fibrosis. *Br J Ind Med*. 1987 Oct; 44(10): 661-72.
20. Kuempel ED, Stayner LT, Attfield MD, Buncher CR: Exposure-response analysis of mortality among coal miners in united states. *Am J Ind Med* 28: 167-184, 1995.
21. Miller BG, Jacobsen M: Dust exposure pneumoconiosis and mortality of coal miners. *Br J Ind Med* 42: 723-733, 1985.
22. Xiarong Wang, David C. Christiani. Respiratory Symptoms and Functional Status in workers exposed to Silica, Asbestosis and Coal Mine Dust. *J Occup Environ Med*. 2000; 42: 1076-1084.
23. Julia E Richards, Richard A Obenour, Coal Workers Pneumoconiosis. E-medicine instant access to minds of medicine.[online] .last updated February 14 ,2003.
24. Morgan WK, Seaton A: Occupational Lung Diseases. WB Saunders Co; 1975:149-210.
25. Amandus HE, Peterson MR, Richards TB: Health status of anthracite surface coal miners. *Arch Environ Health* 44: 75-81, 1989.
26. Banks DE, Bauer MA, Castellon RM, Lapp NL: Silicosis in surface coal mine drillers. *Thorax* 38: 275-278, 1983.
27. Lewis S, Bennet J, Richards K, Britton J.. A cross-sectional study of the independent effect of occupation on lung function in British coal miners. *Occup Environ Med* 1996; 53: 125-128.
28. TT Bauer, G Schultze- Werninghaus, J-Killmer, A- Weber et al . Functional variables associated with clinical grades of dyspnoea in coal miners with pneumoconiosis and mild bronchial obstruction. *Occup Environ Med*. 2001;58: 794-799.
29. Carta P, Aru G, Barberi MT, Avataneo G, Casula D. Dust exposure, respiratory symptoms, and longitudinal decline of lung function in young coal miners. *Occup Environ Med*. 1996 May; 53(5): 312-329.
30. Henneberger PK, Attfield MD. 1997. Respiratory symptoms and spirometry in experienced coal miners: effects of the distant and recent coal mine dust exposure. *Am J Ind Med* 32: 268-274.
31. Rosenstock L, Barnhart S, Heyer NJ, Pierson DJ, Hudson LD. The relation among pulmonary function, chest roentgenographic abnormalities, and smoking status on an asbestos- exposed cohort. *Am Rev Respir Dis*. 1988; 138: 272-277.
32. Killburn KH, Warshaw RH. Correlation of pulmonary functional impairment with radiographic asbestosis. *Am Rev Respir Dis*. 1989; 139: A210.
33. Parker JE, Banks DE. Lung disease in coal workers. In : Banks DE, Parker JE, eds. *Occupational Lung Disease: An International Perspective*. London: Chapman & Hall Medical; 1999:161-181.
34. Marine WM, Gurr D, Jacobsen M, Clinically important respiratory effects of dust exposure and smoking in British miners . *Am Rev Respir Dis*. 1988; 137: 106-112.
35. Sexias NS, Robins TG, Attfield MD, Moulton LH. Longitudinal and cross sectional analyses of exposure to coal mine dust and pulmonary function in new miners. *Br J Ind Med*. 1993; 50: 312- 329.