Study of Pulmonary Function Tests in Steel Plant Workers

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ABSTRACT

Background: *Numerous cross-sectional studies have reported reduced lung function among steel plant workers but limitations of exposure assessment and design preclude causal inference.*
The aim of this study was to assess pulmonary function of steel plant workers exposed to fine inorganic metal dust in working environment.

Methods: *Demographic characteristics of employees in a steel plant were recorded & their lung function was measured by spirometry using RMS Spirometer. Collected data was analyzed by statistical methods.*

Results: *Among the workers FEV1, PEFR, FEF25-75 was significantly reduced whereas FEV1/FVC was normal.*

Conclusion: *Exposure to mineral dust in steel plant over a prolonged period results in decline of lung function. Periodic assessment of such workers with spirometry should be undertaken to detect it early and to take appropriate corrective & preventive measures.*

Keywords: *Steel plant worker, Spirometry, Pulmonary function test, Dust exposure*

INTRODUCTION

The respiratory health effects have been documented in workers exposed to a variety of inorganic dusts in small and large-scale industries, which generate dust during their production process. The diseases of the respiratory system induced by occupational dusts are influenced by the type of the inorganic dust, dose, duration of exposure and genetic factors[1,2]. The main components of welding emissions are oxides of metals due to contact between the oxygen in the air and the vaporized metals. The fume particulates and gases including ozone and nitrogen oxides may cause inflammation and oxidative damage to the airways[3,4]. Occupational diseases are caused by a pathologic response of the patients to their working environment[5]. Many metals such as chromium, brass, nickel, phosphorus, copper, iron and aluminum are used in the manufacture of the steel industry workers in the developing countries are often exposed to high concentrations of dusts and fumes that affect pulmonary function[6]. Such processes are thought to be closely linked to the pathogenesis of chronic obstructive pulmonary disease[7,8] Data from population based studies[9,10,11] and cross-sectional studies of working populations[12,13,14,15] have indicated a long term effect on lung function from exposure to welding fumes and gases although the evidence is not entirely consistent[16]. Others have suggested an interaction between smoking and welding exposure on the prevalence of pulmonary impairment [17].

In occupational Respiratory disease, spirometry is one of the most important diagnostic tools. Measurement of dynamic lung functions is more important than of static lung volumes. Lung function tests are beneficial in the early recognition of pulmonary dysfunctions even if the workers may be normal clinically[18]. This study is conducted to investigate the effects of exposure to metal dust on respiratory symptoms and lung function of steel plant workers in Wardha, Maharashtra and to assess the additive effect of smoking on pulmonary function parameters.

METHODS

Study Population

All the workers in the steel plant were invited to participate in the study; only those workers who were on leave on the days of the study & suffering from some acute illness did not take part. An appointment was made with the supervisors to conduct the study on specified days during the study period. The ethics committee of the medical faculty had earlier given clearance for the procedures to be applied in this study including the questionnaire, and the work was conducted from August 2014 to December 2014. The exposure groups as used in this analysis consist of many different occupations with different exposure levels over many years.

Lung Function Measurements

The pulmonary functions were carried out using RMS Spirometer. The subject's age (years), height (cm) and weight (Kg) were recorded & fed into the machine and the machine automatically gave the predicted values corresponding to that age, weight and height thereby removing these confounding factors.

The subjects were instructed to apply nose-clip to prevent air leak and hold the mouth piece closely to the lips. The procedure was explained in detail and demonstrated to them prior to the commencement of each test and maximum effort on behalf of the subject was emphasized.

The Parameters Recorded Were

1. FEV_1 (Forced expiratory volume in first second),
2. FEV_1/FVC,
3. FEF25-75% (Forced mid-expiratory flow rate),
4. PEFR (Peak expiratory flow rate).

For each parameter predicted, measured & percent predicted values are taken.

Each test was repeated thrice and spirometric indices were calculated using best out of 3 technically satisfactory performances as per recommendations of American Thoracic Society[19].

For recording of FEV_1, FEF 25-75% and PEFR the subjects were asked to breathe in and out normally into the mouth piece. Then the subject was asked to take deep breath to fill lungs to maximum possible and then exhale into the mouth piece as quickly as possible. All the subjects made three such attempts and the best of the three was selected.

Smoking Assessment

Along with age, height and occupational factors, smoking is recognized as a major determinant of lung function[20,21,22]. Surveillance data only provided information, obtained at the dates of last sets of tests, on smoking status (non, ex, or current), the daily smoking level for current smokers only, and smoking years for both current and ex-smokers.

Questionnaire

Data on smoking, respiratory symptoms, and diseases were collected by a face-to-face interview with questions based on the 1987 version of the European Coal and Steel Community respiratory questionnaire[23]. Non-smokers were defined as those who had never smoked regularly. Smokers were those who reported currently smoking at least one cigarette daily. Ex-smokers included those who had formerly smoked regularly.

Statistical Analysis

Statistical analysis was done by using descriptive and inferential statistics using Chi-square test, Pearson's correlation coefficient and linear regression analysis. The software used in the analysis was SPSS17.0 version and $p<0.05$ is considered as level of significance.

RESULTS

Population Characteristics

Of the 450 men, 04 workers were absent and 10 were suffering from fever on the study day. Thus, the final study group included 436 subjects.

Table 1: Age wise distribution of patients

Age Group(yrs)	No of workers	In Percentage
18-27 yrs	128	29.36
28-37 yrs	213	48.85
38-47 yrs	68	15.60
48-57 yrs	19	4.36
58-67 yrs	7	1.61
>67 yrs	1	0.23
Total	436	100.0
Mean Age	32.61	
SD	8.20	

Table 1 represents age wise distribution of the workers. The study population was divided into seven groups with mean age 32.61 years and standard deviation(S D) 8.20. Maximum population was relatively young, i.e. from the age group of 28 -37 (48.85%).

Graph 1: Age wise distribution of workers

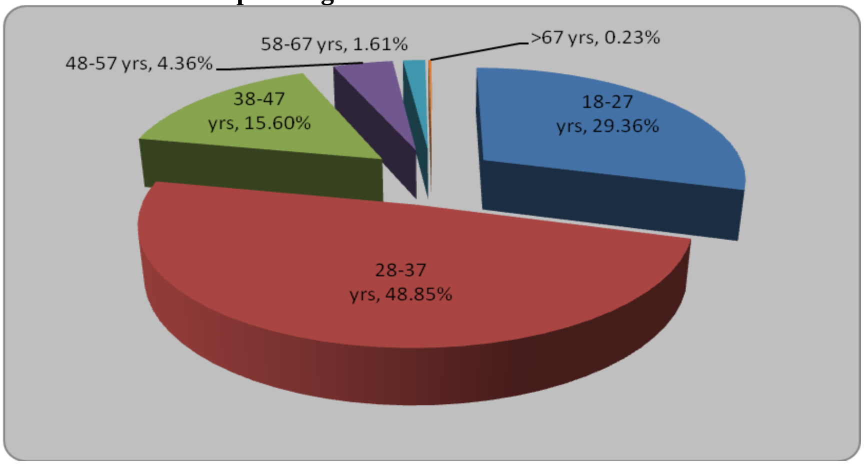

Table 2: Distribution of workers according to working duration in the plant

Years of working in plant	No of workers (%)
Upto 10 yrs	306 (70.18)
11-20 yrs	93 (21.33)
21-30 yrs	29 (6.65)
31-40 yrs	8 (1.83)
Total	436
Mean	8.97
SD	6.94(0.20-40 years)

Table 2 shows the total years of exposure in the steel plant. Maximum population (306 workers) had exposure of less than 10 years. Mean exposure was 8.94 years with SD 6.94.

Table 3: Correlation coefficient between FEV1 predicted and measured value

FEV1	Mean	SD	Correlation 'r'	p-value
Predicted	2.98	0.35	0.572	0.000 S, p<0.05
Measured	2.82	0.55		

Regression equation is FEV1 Predicted= 0.12 - 0.90* FEV1 Measured.

Table 3 shows the correlation coefficient for FEV1 predicted is 2.98 mean and S.D. is 0.35.
Measured 2.82 mean and S.D. is 0.35 with correlation r is 0.572 and p value is 0.00 that is non-significant.
FEV1 measured is decreased as compare to their predicted.

Table 4: Correlation coefficient between FEV1 predicted and measured value

Rating	Obstruction % Predicted FEV1	Number of workers (%)
Possible normal variant	>80	369(84.63%)
Mild	70-80	39(8.94%)
Moderate	50-70	23(5.28%)
Severe	35-50	1(0.23%)
Very Severe	<35	4(0.92%)
Total	436	436(100%)

Table 4 represents FEV1 values mild, moderate & severe obstruction and majority of cases (84.63%) showed FEV1>80% of predicted.

Table 5: Correlation coefficient between FEV1/FVC predicted and measured ratio

FEV1/FVC	Mean	SD	Correlation 'r'	p-value
Predicted	83.71	4.54	0.09	0.05 NS, p>0.05
Measured	82.32	8.98		

Regression Equation
FEV1/FVC Predicted = 66.80 - 0.18* FEV1/FVC Measured

Table 6: Correlation coefficient between FEV1/FVC ratio of predicted and measured values

Rating	Obstruction % Predicted FEV1/FVC	Number of workers (%)
Possible normal variant	>80	426(97.71%)
Mild	70-80	4(0.92%)
Moderate	50-70	4(0.92%)
Severe	35-50	0(0%)
Very Severe	<35	2(0.46%)
Total	436	436(100%)

Table 7: Correlation coefficient between FEF25-75 of predicted and measured ratio

FEF25-75	Mean	SD	Correlation 'r'	p-value
Predicted	4.45	3.87	0.10	0.034 S,p<0.05
Measured	3.15	0.97		

Regression Equation
FEF25-75 Predicted = 3.04 + 0.02* FEF25-75 Measured

Table 8: Correlation coefficient between FEF25-75 predicted and measured value

Rating	Obstruction % Predicted FEF25-75	Number (%)
Possible normal variant	>80	159(36.47%)
Mild	70-80	78(17.89%)
Moderate	50-70	139(31.88%)
Severe	35-50	48(11.01%)
Very Severe	<35	12(2.75%)
Total	436	436(100%)

Table 9: Correlation coefficient between PEFR predicted and measured ratio

PEFR	Mean	SD	Correlation 'r'	p-value
Predicted	9.09	0.72	0.29	0.000 S,p<0.05
Measured	7.13	1.52		

Regression Equation
PEFR Predicted = 1.41 + 0.62* PEFR Measured

Baseline Level of Pulmonary Function
1. Overall FEV1 and FEV1/FVC was lower with mean of FEV1 predicted is 2.98 and measured is 2.82. For FEV1/FVC mean of predicted is 83.71 and measured is 82.32 but none of them showed obstructive pattern. FEV1/FVC is >80% of predicted in 98% of cases.
2. FEF25-75 and PEFR is significantly decreased, mean of FEF25-75 predicted is 4.45 and measured is 3.15. For PEFR mean of predicted is 9.09 and measured is 7.13.
3. FEF25-75 is significantly lowered in 78 cases (17.89%) showed mild small airway obstruction and 139 cases (31.88%) showed moderate obstruction.
4. PEFR was also significantly reduced. Mild small airway obstruction was found in 111 workers (25.46%) and in 100 workers (22.94%) moderate obstruction was observed.

DISCUSSION
The purpose of the present study was to assess lung function of steel plant workers exposed to fine inorganic metal dust during working. A cross-sectional study was conducted among 436 steel plant workers.
The still plant workers are exposed to dust, fumes, and gases comprising silica, carbon, iron, and manganese. Dusts, fumes, and manganese have been reported to have an adverse affect on the lung function of workers exposed to these agents[23,24,25,26].

In this study FEV1 and FEV1/FVC values were slightly reduced as compared to their predicted values whereas FEF25-75 and PEFR were significantly reduced. FEV1 and FEV1/FVC are slightly reduced due to good working condition, all the participants are educated hence adequate use of preventive measures used, and in our study maximum population (78.21%) belongs to young age with maximum exposure upto 10 years. FEF25-75 and PEFR are significantly reduced and showed early small airway obstruction in asymptomatic cases.
Our findings are consistent with those from Akbar-Khanzadeh who have also reported a greater deterioration of lung function in welders[27]. Meo et al in a *cross-sectional* study of 50 non-smoking manual metal arc welders and 50 non-smoking controls found a significant smaller lung functions among welders exposed for more than 9 year (640 ml in FEV1), suggesting an independent effect of welding fumes on the lungs[28]. Sigve W Christensen et al in his study found decline in lung function that is FEV1 in workers exposed to welding emissions[29]. B NEMERY et al have also found decrement in FEF25-75 of steel plant workers from a strand casting department[25]. In another cross-sectional study, exposure to dusts in steel workers has also been strongly associated with reductions in FEV1. Significant decreases in FEV1 have been associated with increases in occupational exposures to gases and fumes[30]. Combined occupational exposures to mineral dusts and gases have been reported to reduce peak expiratory flow rate (PEF) which is also observed in our study[31]. J Gomes et al also found decline in lung

functions (FEV1, PEFR, and FEF25-75) in iron foundry workers, the similar findings have been recorded in our study[32].

CONCLUSION

In conclusion, we found some indications of a limited accelerated loss in lung function that is early small airway obstruction among asymptomatic young and middle-aged workers. As opposed to fume exposure smoking did significantly contribute to accelerated decline in lung function.

It is recommended that these workers should be followed up at periodic intervals in future to further assess their decline of lung function.

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