

DYNAMIC LUNG PROFILE IN SUGARCANE INDUSTRY WORKERS

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ABSTRACT

Context: Airway diseases are commonly encountered with people exposed to dust constantly, which over a period of time may affect lung function. **Objective:** To study the lung function profile in asymptomatic sugarcane industry workers to find out airway diseases if any, and their correlation with duration of exposure to the dust. **Design:** The pulmonary function tests were studied with MEDSPIROR, in age matched sugar factory male workers exposed to sugarcane dust (n=95), and normal healthy controls (n=100) from Marathwada region of Maharashtra, during years 2009 to 2010. The cases and controls were chosen upon detailed history. Cases and controls were divided in 3 groups namely 15 to 25 years, 26 to 35 years and more than 35 years to study various parameters like FVC, PEFR, FEF 25 – 75, FEV1 % & MVV among cases compared with age matched controls. Another distribution was done according to the duration of exposure amongst the cases 1-4 years n=48, 5 – 9 years n=25 and > 9 years n=22. **Main outcome of the study:** Lung functions were found to be reduced in all cases as indicated by different parameters of PFT. **Results:** A highly significant decrease in FVC and PEFR in all age groups, even MVV and FEF 25 – 75 showed a highly significant decline in first two groups and a significant decline in the third. There was a non significant increase in FEV1 % in the first two groups whereas a non-significant decline in cases above 35 years when compared with age matched controls. There was a highly significant decline in FVC amongst the cases when compared with increasing duration of exposure, although other parameters also showed a non significant decline. **Conclusion:** It may be concluded that the decline in PFT parameters in all the age groups is suggestive of restrictive and obstructive changes and with predominance of parenchymatous lesions when exposed to mouldy bagasse for longer duration.

KEY WORDS: Pulmonary function tests, Bagassosis, Airway disease

INTRODUCTION

Today industrialization is emerging as a new culture of modern society. Along with the economical rise and development, the industrial revolution has brought about tremendous change in the ecology and environment of man. But somewhere along it, the health aspect is overlooked.

Most commonly and easily affected are the lungs due to any organic or inorganic dust to which the workers are exposed. It is well known that the industrial dust inhalation over a long period leads to proliferative and fibrotic changes in the lungs. Talking of exposure to dust, it was found that the frequency of respiratory illness was greater among the exposed workers than non-exposed.

Significance of pulmonary function in assessing responses to various airborne pollutants has been known since middle of the 20th century, and large number of studies have been undertaken to assess the effect of dust on lung functions in various occupations.

India has a large sugarcane industry and Maharashtra being one of the largest sugar producers, many people are engaged in this work. Inhalation of bagasse dust causes disease of respiratory system known as "Bagassosis" which is nowadays described under the broad heading of hypersensitivity pneumonitis and is also termed as a variant of farmers' lung¹. The cane sugar is not only utilized for production of sugar, but also the fiber which until recently went to a waste is now utilized in the manufacture of paper, cardboard and rayon and therefore bagassosis is seen in all these industries also.

Till now, many researchers have worked on the effect of different organic dusts on pulmonary function overlooking bagassosis as minor ailment. The

studies conducted in western countries on spirometer reported reduced FVC^{2,3,4,5}, FEV1^{6,7,8} MVV^{2,9,10}, PEFR⁹. But due to better storing and operating conditions, bagassosis is perhaps eliminated from these countries as no more studies were reported after 1971.

In India, Vishwanathan et al¹¹ and Nair and Das⁹ in 1970 reported reduced VC, TLC, PEFR, and MVV in patients in bagassosis. Since 1970 no more pulmonary function studies were reported in this field in India until recently in 2008 a study was reported from western Maharashtra by Patil S N¹² showing decrease in FVC, FEV1, PEFR and MVV in exposed group as compared to non exposed group to bagasse.

In 1971, Miller and Ashcroft¹³ conducted a community survey of respiratory diseases among Indian and African adults employed in sugar industry of Guyana. Symptoms occurred in Indians significantly, but none was seen in Africans employed, suggesting Indians are more susceptible for respiratory involvement by sugarcane dust.

The limitations of all above studies were that they were not conducted on a large study group and were not compared with controls of same age, height, weight, and socioeconomic status. The results were also not subjected to statistical analysis. The apparatus used was either a spirometer or respirometer, which gave very limited information regarding pulmonary function tests.

The present study is conducted on a large group and is done on a very sensitive apparatus "Medspiror" which gives many other significant parameters of respiratory function tests chosen for this study like FVC, FEV1%, FEF25-75, PEFR and MVV to assess the effect of bagasse dust. Of these FEF 25-75 has not been evaluated so far. It is a sensitive index indicating small airway obstruction resulting from hypersensitivity pneumonitis.

Also a study conducted by Miller & Hearn⁷ showed a significant reduction in ventilatory capacity in workers exposed to bagasse dust without symptoms. Hence, the present study is conducted on asymptomatic workers exposed to bagasse dust.

MATERIALS AND METHODS

The present study was conducted at sugar mills in Maharashtra. The pulmonary function tests were carried out in 195 males out of which 95 were workers and 100 served as non-worker controls with same age and socioeconomic status. Workers were divided in 3 groups namely 15 to 25 years (n=44), 26 to 35 years (n=28) and more than 35 years (n=23) and similar division was done for controls (n=40, 27 and 33, respectively) in three age groups. Another distribution was done according to the duration of exposure amongst the cases 1-4 years (n=48), 5 – 9 years (n=25) and > 9 years (n=22).

Selection of cases was done by excluding:

1. Those having cardiovascular illness in present or past.
2. Those having respiratory symptoms in present or past in order to exclude decrease in pulmonary function test due to respiratory illnesses other than bagassosis.
3. Those having kyphoscoliosis or asthma.
4. Those having addiction of smoking and alcohol.

As the cases are labour class, there was habit of tobacco chewing and slight intake of alcohol which does not alter or affect the pulmonary function tests. This habit was in both the groups, cases as well as controls which nullifies the effect.

Selection criteria for work done by cases:

Only those workers were taken, who were exposed to dry and mouldy bagasse while:

1. Removing bales from stacks.
2. In compressing operations.
3. In opening and shredding of bales.
4. Hammer milling bagasse.
5. Transporting bales to the vehicles

Anthropometric measurements (height and weight) were taken and BMI was calculated as: BMI = WEIGHT(KGS)/HEIGHT(MTS)

Pulmonary function tests were done by 'MEDSPIROR' a computerized pneumotachometer (manufactured by Med. System Pvt. Ltd, Chandigarh) at room

temperature 28-30°C between 10.00 am to 3.00 pm.

The subjects were given information regarding the procedure and instructions as to what they have to perform, which was helped out by demonstrations also. The readings were taken in a comfortable upright sitting position. Each subject was asked to perform the following two maneuvers:

- a) Forced expiratory maneuver: Subject was asked to take a maximum inspiration and pinch his nose, and then expire forcefully and completely in the mouthpiece of the instrument.
- b) Maximum ventilation volume maneuver: Subject was asked to take a maximum inspiration and pinch his nose, and expire as deeply and rapidly as possible for 6 seconds in the mouthpiece.

Following are the parameters chosen for the study, which are more relevant and pertinent to the study:

FVC (Lit)

FEV1%

PEFR (L/Sec)

FEF25-75 (L/Sec)

MVV (L/Sec)

For each subject a graphical representation and tabular form of all respiratory function parameters of observed, predicted and percentage predicted values were taken and then the same maneuvers were repeated in the next case with a different and sterile mouthpiece. Ethical clearance was obtained from the institutional ethics committee before the commencement of the study.

Statistical analysis of data

Observations are expressed as mean \pm S.D Data was compiled using Microsoft Office 2003 Excel Software. Statistical analysis was done using students' unpaired 't' test and one way ANOVA test.

RESULTS

In Table-1, Table-2 and Table-3, all the three age matched groups show a highly significant decrease in FVC (in 15-25 years 2.00 ± 0.56 , in 26-35 years 1.92 ± 0.66 and >35 years 1.89 ± 0.53) when compared with controls (2.99 ± 0.45 ; 3.13 ± 0.36 ;

2.80 ± 0.45 respectively). Similar such highly significant decrease was also seen in PEFR (5.25 ± 1.64 ; 4.79 ± 1.79 ; 5.37 ± 2.10) when compared with age matched controls. MVV (95.52 ± 31.76 ; 81.31 ± 30.43 ; 81.43 ± 32.05) and FEF25-75 (3.19 ± 1.30 ; 2.92 ± 1.18 ; 2.68 ± 1.42) also showed a highly significant decrease in the age group of 15-25 years and 26-35 years but a significant decrease in >35 years group. A non significant increase in FEV1/FVC was seen in 15-25 years and 26-35 years whereas a non significant decrease in cases >35 years.

Table-4 shows the effect of duration of exposure on parameters of pulmonary function tests. There is a clear decline in all the parameters with increasing duration of exposure although non significant except for FVC which showed a highly significant decrease when a comparison was done amongst the cases with increasing duration of exposure.

DISCUSSION

In the present study, FVC showed a highly significant decrease in all the age groups when compared with age matched controls. A similar statistically significant decline in FVC was reported by Weill et al¹⁰, Alan K. Pierce et al¹⁴, G. J. Miller⁷ and Hur T. et al¹⁵ in acute and chronic cases of bagassosis with symptoms. Our study also correlates with Hearn¹⁶ who reported a similar significant decline in ventilatory capacity in symptomless workers.

Intermittent exposure to antigen or continuous and prolonged exposure to small amount of antigen results in intense immunological reactions within the lung causing irreversible damage to it¹⁷. There are evidences of interstitial fibrosis with granuloma formation, and alveolar wall thickened by infiltration with lymphocytes, plasma cells and eosinophils^{1, 17}. Perhaps similar changes contribute towards low FVC in the present study.

Mechanism remains the same for all the three age groups.

The increase in FEV1% in present study in age groups 15-25 years and 26-35 years although was non significant but still can be compared with studies of 18 cases of Weill et al¹⁰ and G.J. Miller⁷.

As quoted by Alfred Fishman, stating FEV1 might be low due to low vital capacity but FEV1% may exceed the normal range¹⁸. FEV1 is known to be reduced in both central and peripheral airway obstruction, and a low FVC indicates restrictive changes¹⁹. Perhaps workers in the 15-25 and 26-35 years might be having degree of air way obstruction less as compared to restrictive changes there by explaining slight increase in FEV1%. The non significant decrease in the present study in the age group of >35 years was similarly reported by few patients of Weill et al¹⁰, who showed a characteristic obstructive lesion. It can be :

Due to repeated attacks, which destroys respiratory tissue and induces a chronic spreading fibrosis, which destroys alveoli as well as bronchioles as a result of allergic alveolitis²⁰.

Due to inflammatory responses and destruction of alveoli there is decreased diffusion capacity of the alveolocapillary membrane leading to decreased O₂ saturation of blood^{2, 15, 7}. Resulting hypoxia and the associated hyperapnea gives rise to decrease in PACO₂, which also induces constriction of bronchial muscles²¹. Hypoxia leads to release of leukotriens and chemokines²² from eosinophils resulting in broncho-constriction. The walls of bronchioles may be thickened by lymphocytic infiltration and the lumen may be obstructed by granulation tissue¹⁷.

A highly significant decrease in PEFr, observed in present study in all the three age groups was also reported in by Patil S.N.¹² in their study. Although a decrease in PEFr was reported by Nair and Das⁹ and Vishwanathan et al¹¹, but as these studies were not compared with controls and also the test of significance was not applied, therefore they are not comparable.

PEFr is more effort dependent and is an index of expiratory airway resistance¹⁹. The reduction in PEFr may be because of the mechanism already explained for obstructive lesion (FEV1/FVC %). In addition, proteins released from eosinophils in the inflammatory reaction might contribute to the hyper responsiveness of airways²². Muscle weakness due to loss of appetite may effect in lowering PEFr.

FEF 25-75 or maximum mid expiratory flow rate measures the air flow during the effort independent part of the FVC, when the small airways contribute substantially to the limitation of airflow¹⁸. The highly significant decline in age groups of 15-25 year & 26-35 years and a significant decline in >35 years can be explained by the pathological findings in the lungs:

There is evidence of cellular infiltration in the walls of respiratory bronchioles leading to formation of epitheloid granulomas¹⁷. Bronchiolar inflammation with its products and lymphocytes and granulomatous reactions may occlude the smallest airways¹.

MVV is effort dependent and therefore depends on strength of diaphragm and chest muscles on one hand and pulmonary compliance and airway patency on the other hand¹⁹. It provides an over all assessment of effort, coordination and elastic and flow resistive properties of respiratory system¹⁸. A similar decline as in our study was also shown by Weill et al¹⁰ which can be explained on the basis of pathological findings suggestive of restrictive changes as demonstrated by decreased FVC and MVV, and obstructive changes by decreased FEF25-75, and PEFr and FEV1%.

When comparison was done amongst the cases depending upon duration of exposure it was FVC that showed a highly significant decline. No such study was done in the past to compare the present one. A significant reduction only in FVC clearly indicates that with increasing duration, parenchymatous lesions are perhaps more prominent than obstructive lesion. It can be supported by the views of Bradford et al²³ and Buechner et al²⁴ which states that repeated exposures result in generalized pulmonary fibrosis and permanent pulmonary insufficiency of various degrees.

CONCLUSION

The present study implies that the decline in FVC, PEFr, FEF 25 - 75 and MVV in all the three age groups is suggestive of restrictive as well as obstructive changes. A decline in FEV1 % although was non significant with increasing age but is suggestive of beginning of obstructive changes. The significant decline in FVC with increasing duration of

exposure is an indication of predominance of parenchymatous lesions with long term exposure to mouldy bagasse. The data generated by the present study might be useful for understanding the dynamic lung profile in obstructive and restrictive lung diseases and also anticipating underlying slowly progressive pathological changes in the lung tissue in occupations involving exposure to dusty conditions.

GROUPS	FVC (Lit)	PEFR (Lit/s)	FEF 25-75 (Lit/s)	FEV1/FVC %	MVV (Lit/min)
Control (N=40)	2.99 ± 0.45	7.97 ± 1.19	4.29 ± 1.03	95.55 ± 4.42	116.63 ± 20.77
Case (N=44)	2.00 ± 0.56	5.25 ± 1.64	3.19 ± 1.30	95.65 ± 7.7	95.52 ± 31.76
P value	< 0.0001	< 0.0001	< 0.0001	0.9439	< 0.001
Significance	H S	H S	H S	N S	H S

Table 1 - COMPARISON OF PFT PARAMETERS BELONGING TO AGE GROUP 15 TO 25 YEARS

HS – Highly Significant (P<0.001); NS – Not Significant (p>0.05)

GROUPS	FVC (Lit)	PEFR (Lit/s)	FEF 25-75 (Lit/s)	FEV1/FVC %	MVV (Lit/min)
Control (N=27)	3.13 ± 0.36	8.12 ± 1.41	4.34 ± 1.14	94.65 ± 4.88	118.36 ± 25.67
Case (N=28)	1.92 ± 0.66	4.79 ± 1.79	2.92 ± 1.18	95.31 ± 7.01	81.31 ± 30.43
P value	< 0.0001	< 0.0001	< 0.001	0.6935	< 0.001
Significance	H S	H S	H S	N S	H S

Table 2 - COMPARISON OF PFT PARAMETERS BELONGING TO AGE GROUP 26 TO 35 YEARS

HS – Highly Significant; NS – Not Significant (p>0.05)

GROUPS	FVC (Lit)	PEFR (Lit/s)	FEF 25-75 (Lit/s)	FEV1/FVC %	MVV (Lit/min)
Control (N=33)	2.80 ± 0.45	7.46 ± 1.21	3.65 ± 0.96	94.36 ± 4.88	110.44 ± 23.44
Case (N=23)	1.89 ± 0.53	5.37 ± 2.10	2.68 ± 1.42	91.11 ± 11.21	81.43 ± 32.05
P value	< 0.0001	< 0.0001	< 0.0043	0.1524	< 0.003
Significance	H S	H S	S	N S	S

Table 3 - COMPARISON OF PFT PARAMETERS BELONGING TO AGE GROUP > 35 YEARS

HS – Highly Significant; NS – Not Significant;
S – Significant (p<0.05).

EXPOSURE	FVC	PEFR	FEF 25 – 75	FEV1/FVC %	MVV
1 – 4 yrs (n=48)	2.17 ± 0.58	5.46 ± 1.61	3.28 ± 1.26	96.05 ± 6.17	94.54 ± 28.46
5 – 9 yrs (n=25)	1.72 ± 0.58	4.83 ± 2.02	2.78 ± 1.45	93.55 ± 10.21	81.93 ± 36.61
> 9 yrs (n=22)	1.70 ± 0.39	4.82 ± 1.89	2.58 ± 1.08	91.62 ± 11.31	80.28 ± 31.64
F ratio	7.6	1.41	2.58	2.018	2.088
Significance	HS	NS	NS	NS	NS

Table 4 –COMPARISON OF PFT PARAMETERS ACCORDING TO THE EXPOSURE OF CASES:

HS – Highly Significant; NS – Not Significant;

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