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Original Article

"A correlative study of spirometric parameters and ECG changes in patients with chronic obstructive pulmonary disease"

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ABSTRACT

Context: Chronic obstructive pulmonary disease (COPD) is the fourth leading cause of death world over. COPD has been defined as a disease state characterized by airflow limitation. Spirometric tests like Forced Expiratory Volume in first second (FEV1) < 80% and FEV1/FVC (ratio of Forced Expiratory Volume in first second to the Fixed Vital Capacity) 0.7 is the diagnostic criteria for COPD. COPD influences the electrical events of the heart. Aims: The objective was to observe ECG (electrocardiogram) changes and severity pattern by spirometry and to correlate the spirometric parameters with ECG changes. Settings and Design: A prospective cross sectional case control study. Methods and Material: 50 cases were selected on the basis of simple random sampling method. The FEV1, FEV1/FVC ratio and ECG changes such as P wave axis, QRS axis, P wave height ≥ 2.5 mm and etc. were studied and the group of 20 non smoker healthy subjects were selected as a control. Spirometric parameters were correlated with ECG changes. Statistical analysis: Correlation between two variables were performed by Pearson's correlation co-efficient "r". Results: Majority of the patients had moderate (50%) and severe (42%) airflow limitation. The most common ECG changes were P wave axis ≥ $+90^0$ (66%), QRS axis > +90 (42%), P wave height ≥ 2.5 mm in lead II (42%). ECG changes significantly correlated with low values of FEV1/FVC ratio. Conclusion: Not only FEV1 and FEV1/FVC ratio helps to assess the severity of the disease, but also ECG would reflect the severity of COPD. Key Message: ECG findings were significantly correlated with low values of FEV1/FVC ratio. It can be concluded that ECG can be used to assess the severity of COPD, wherever spirometry is not possible.

1. Introduction

Chronic obstructive pulmonary disease (COPD) is a common and preventable disease, that has great implications on global health. It is the fourth leading cause of death world over, exceeded only by myocardial infarction, malignancy and stroke [1]. COPD is associated with abnormal inflammatory response of the lungs to chronic inhalation exposure from smoke, dust and other air pollutants. Since the airway obstruction associated with COPD is not amenable to treatment, the best approach is prevention.

The major morbidity of COPD is due to the impact on cardiac performances, which is directly due to pulmonary arterial hypertension. Several studies reported changes in the activity of heart including P-wave axis and amplitude, rightward displacement of QRS, reduction of amplitude of QRS complex in limb and precordial leads etc., among COPD patients. However, COPD patients probably are not usually assessed by electrocardiogram in routine medical practice particularly in developing countries like India. Therefore, the present study was conducted to evaluate the diagnostic values of ECG changes and also it would be of great importance, if it can be established that a high degree of correlation between ECG and spirometric parameters which indicate the severity of COPD.

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2.Materials and Methods

In this study, 50 cases were selected on the basis of simple random sampling method from the Medical Wards, K.R. Hospital, Mysore from June 2005 to March 2006.

As per GOLD (Global Initiative for Chronic Obstructive lung disease) guidelines [2] of COPD, any patient who has symptoms of chronic cough, sputum production, or dyspnoea, and / or a history of exposure to risk factors for the disease are considered and included in the study, and was further confirmed by spirometry. The values of Forced Expiratory Volume in first second (FEV1) less than 80% of the expected value and ratio of forced expiratory volume in first second to the fixed vital capacity (FEV1/FVC) less than 0.7 (70%), after post bronchodilator inhalation were included in this study. Patients with Bronchial asthma, Pulmonary tuberculosis, Bronchectasis, known congenital or acquired heart diseases, Diabetes mellitus and Hypertension, were excluded, and 20 non smoker healthy subjects were selected as a control group.

After applying above inclusion and exclusion criteria, the 50 patients were subjected for detailed history and thorough clinical examination including anthropometry was done. Chest X-ray – postero-anterior view was obtained to detect features of the emphysema and chronic bronchitis as per Simon's criteria [3]. Radiological evidence for right heart enlargement was also looked for. Spirometry was done on computerized spirometer (kit micro, COSMED, Srl, Rome Italy). Spirometry was performed when the patients were clinically stable with prior proper instructions as per ATS (American Thoracic Society) guidelines [4].

The computerized spirometry gives age, sex, race, weight and height matched predicted and test values. The best of the three attempts was selected. In spirometry, the forced expiratory volume in first second and FEV_1/FVC ratio were studied and analyzed, categorized as per GOLD staging, Bronchodilator Reversibility Testing was also performed. A standard 12 lead electrocardiogram (ECG) was obtained from all cases as well as controls. ECG was analyzed in detail for P wave axis $\geq +90^0$, QRS axis > +90, P wave height 2.5 mm in lead II, R wave in $V_6 \leq 5$ mm, R/S ratio in $V_5V_6 \leq 1$, RBBB, R wave $V_1 > 7$ mm in COPD patients.

Written consent was taken from both cases and controls, ethical committee clearance were also obtained.

2.1.Statistical analysis

Comparison of various parameters among male and female subjects with COPD were performed by "t" test, correlation between two variables were performed by Pearson's correlation co-efficient "r", analysis was done by using SPSS+ 10.0 computer package for statistics.

3.Results

Fifty cases of COPD were studied and the following observations were made. Out of 50 cases studied males were 44 and female patients were 6 in number, among controls males were 16 and females were 4 in number. Majority of the patients in the cases studied were males constituting 88%. The male female ratio was 6.33:1. Mean age of the male patients among cases was 63.32 10.73 years and that of the female in the study was 63 10.18 years. The mean age of the males among controls was 57.8710.20 and that of females was 57.508.20 Majority of male patients were in 51-60 age group. In the present study smoking was the major risk factor and all the 44 male patients were smokers, history of exposure to smoke of burnt fuels was present in all the female cases (Table 1). The p value was <0.005 which was statistically significant. There was a dose response relationship between the number of pack-years of smoking and decline in lung function. In the present study duration of smoking was in the range from 20 packyears to 60 packyears. Majority were in 30-50 packyears of duration of exposure. In the present study cough with expectoration was present in all the patients. Breathlessness was present in 94% of patients, cyanosis was present in 7 cases, pedal oedema and pursed lip breathing was observed in 6 cases and indrawing of intercostal muscles was seen in 5 cases and raised JVP in 5 cases and clubbing in one case.

Chronic bronchitis with emphysema were observed among 56% of patients in chest x- ray,. 22% had chronic bronchitis, 22% had normal chest x-ray. Chest x ray of all the control group were normal.

Though there are many spirometric parameters, the FEV_1 and FEV_1/FVC ratio are often considered as indices of pulmonary function in chronic obstructive pulmonary disease. FEV_1 reflects

Table 1 : Risk factors for COPD

	Male	Female	Total	Percentage
History of smoking	44	0	44	88
Exposure to smoke of burnt fuels	0	6	6	12
Total	44	6	50	100

Table 2 shows the mean expected FEV_1 among the cases studied was 2.30 ± 0.35 lit and actual mean FEV_1 was 1.12 ± 0.34 lit. The mean FEV_1% of expected value in this study was 49.76 14.25%. FVC reflects the change in vital capacity. The mean expected FVC was 2.92 ± 0.43 lit. The actual mean FVC was 2.22 ± 0.50 lit. The mean FEV_1/FVC ratio was 53.01±14.22 in the present study. All the control group had normal spirometric parameters. Maximum number of patients in the present study were in stage II with 50% of the patients showing moderate air flow obstruction with a mean FEV_1 of 62.08 ± 6.64, 42% of patients had severe obstruction with a mean FEV_1 of 39.17 ± 6.74 and 8% of patients had very severe obstruction of FEV_1 28.37 ± 1.85. (Table 3). None of the patients in the present study had mild airflow obstruction as per GOLD staging.

Table 2 : Range and mean values of spirometric parameters

Test	Range	Mean	Standard deviation
FVC†	1.03-3.21	2.22	0.50
FEV_1†	0.53-1.84	1.12	0.34
FEV_1%	25.70-77.0	49.76	14.25
FEV_1/FVC%	21.50-70.0	53.01	14.22

† = in litres

Table 3 : Patients in different stages of COPD as per GOLD staging criteria2

Stage	Number of patients	Percentage	Mean FEV_1 in % with SD
I- (Mild) FEV_1>80%	-	-	-
II-(Moderate) FEV_1 50-80%	25	50	62.08±6.64
III-(Severe) FEV_1 30-50%	21	42	39.17±6.74
IV-(Very severe) FEV_1<30%	4	8	28.37±1.85

Table 4 shows the most frequent ECG changes observed was P wave axis $\geq +90^0$ (66%), QRS axis > $+90^0$ (42%), P wave height 2.5 mm in lead II (42%), R wave in V6 ≤ 5 mm (34%), R/S ratio in V5V6 1 (28%), Only few patients had R wave in V1> 7 mm and RBBB. However, 32% of the patients had normal ECG. The ECG of all control group was within normal limits.

Table 4: Showing ECG changes in COPD patients

ECG criteria	Number of patients (N=50)	Percentage
P wave axis $\geq +90^0$	33	66
QRS axis > +90	21	42
P wave height ≥ 2.5 mm in lead II	21	42
R wave in V_6 ≤5 mm	17	34
R/S ratio in V_5V_6 ≤1	14	28
R wave V_1 > 7 mm	1	2
RBBB	2	4
Normal ECG	16	32

Table 5: Shows the correlation of ECG changes with FEV1/FVC ratio. There is a significant negative correlation (correlation coefficient "r" value) between the FEV1/FVC% values and the incidence of various electrocardiographic features. The ECG changes were invariably present in COPD patients with low FEV1/FVC% values. ECG changes were almost not seen among COPD patients with high FEV1/FVC% values. This is because the reduction of FEV1/FVC was probably associated with increased residual volume (air trapping).

Table 5: Showing correlation of ECG changes with FEV1/FVC ratio

FEV1/FVC(%)	21-30	31-40	41-50	51-60	61-70	P-value	R-value
P wave axis $\geq +90^0$	3 (100%)	10 (100%)	7 (100%)	7 (58.3%)	6 (42.1%)	0.002(S)	-0.641
QRS axis≥ $+90^0$	3 (100%)	9 (90.0%)	3 (42.9%)	3 (25.0%)	3 (21.4%)	0.001(S)	-0.709
P wave ≥2.5 mm in lead II	3 (100%)	10 (100%)	3 (42.9%)	1 (8.3%)	4 (28.6%)	0.001(S)	-0.670
R wave in V_6 < 5 mm	2 (66.7%)	7 (70.0%)	2 (28.6%)	2 (16.7%)	4 (28.6%)	0.049(NS)	-0.468
R/S ratio in V_5V_6 ≤1	1 (33.3%)	6 (60.0%)	1 (14.3%)	3 (25.0%)	3 (21.4%)	0.0175(NS)	-0.307
R wave in V_1 > 7 mm	-	1 (10.0%)	-	-	-	0.758 (NS)	-0.004
RBBB	-	1 (10.0%) (10.0%)	-	-	1 (7.1%)	0.794 (NS)	-0.187

S Significant; NS Not significant

Table 6: Correlation of FEV1/FVC ratio with ECG changes

FEV1/FVC ratio	V.K. Singh[57] et al.		Present study	
	r-value	p-value	r-value	p-value
P wave axis $\geq +90^0$	-0.695	<0.01	-0.641	0.001
QRS axis $> +90^0$	-0.764	<0.02	-0.709	0.001
P wave height ≥ 2.5 mm in lead II	-0.866	<0.02	-0.670	0.001
R wave in $V_6 < 5$ mm	-0.816	<0.02	-0.468	0.001
R/S ratio in $V_5V_6 \leq 1$	-0.879	<0.02	-0.307	0.030
R wave in $V_1 > 7$ mm	-	-	-0.004	0.976
RBBB	-	-	-0.187	0.194

4. Discussion

COPD is a disease of late adulthood. As the age advances the lung function (FEV1) declines and other risk factors add to the disease process. In the present study the mean age was 63.16±10.45. COPD is a male dominant disease, the high prevalence in males which is due to higher prevalence of smoking in this gender, and also males are more susceptible to smoking than females [5]. In our study males accounted for 88%, with a male-female ratio of 6.33:1. In the present study all males were smokers, 6 females patients were non smokers but all of them were exposed to smoke of burnt fuels which is very common in rural Indian population. In this part of the country, cooking is predominantly by using wood and cow dung. This is possibly a strong risk factor for development of COPD among female patients [6].

Present study consists of mean value of FEV_1 (1.12± 0.34), FVC (2.22 ± 0.50) and FEV_1/FVC% (53.01 ± 14.22). According to GOLD criteria majority of the patients in the present study belong to moderate to severe airflow obstruction, which was comparable with that of MK Tandon [7] and V.K. Singh et al [8] study group which consists of FEV_1/FVC ratio 56.70% and 48.45% respectively. Common ECG abnormality seen were, P wave axis $\geq +90^0$, QRS axis > +90, and P wave ≥ 2.5 mm in lead II, similar findings were seen in Spodicks [9] series, in which 13.9% of COPD patients had P-wave equal or greater than 2.5mm and Carid and Wilcken [10] found incidence of P-pulmonale in 15.5% of their COPD patients, while Scott et al [11] and Pinto et al [12] recorded same incidence of 32.7% in their studies. In our study P wave height ≥ 2.5 mm in lead II was observed in 42% of the patients. The most frequent ECG changes observed was P wave axis $\geq +90^0$ (66%), QRS axis > +90 (42%), R/S ratio in V5V6 ≤ 1 (28%), Calatayud JB et al [13] and Scott RC et al [14] also documented similar changes in P wave pattern, this is mainly due to change in hemodynamics of pulmonary vasculature secondary to hypoxia, pulmonary vascular surface area reduction and also there will be change in cardiac position (dextrorotation). Persistent and progressive change in pulmonary vasculature results in direct effect on cardia in the form of right ventricular hypertrophy and dilation as well as right atrial enlargement [15]. R wave in V6 ≤ 5 mm in 34% of the patients, Silver H.M et al [16] also demonstrated R wave amplitude < 5mm in V6 in their study population. In the present study 4% of patients showed RBBB and 2% of patients showed R wave of ≥ 7 mm in V1.

Thompson HK Jr [17] et al studied 108 patients of chronic obstructive pulmonary disease, and he correlated ECG with pulmonary functions and hemodynamic data. The pathological features of the lungs and heart were also correlated with several electrocardiographic variables.

In our study there was a significant negative correlation between the FEV_1/FVC values and the incidence of various electrocardiographic features and showed similar correlation in the findings of V.K. Singh et al [8] study group. Ruskin et al [18] defined severity in terms of FEVl and RV/TLC (Residual volume and Total lung capacity) ratio. Of severe COPD patients, 66 percent had QRS axis in the 60^0 to 120^0 range, and only 40 percent of mild degree had in this range. As the severity of airflow obstruction increases, ECG changes were seen in majority of the patients. Burrows et al [19] compared subjects with less than 25 percent of predicted FEV_1 to those with greater values of ECG changes, and found statistically significant differences in right axis deviation. Hypoxia is one of the major factor in bringing about ECG changes in COPD. Diagnostic values of ECG among patients with respiratory problems suggest that COPD patients should be screened electrocardiographically in addition to other clinical investigations [20].

5. Conclusions

Computerised spirometry is a very useful investigation in the diagnosis of chronic obstructive pulmonary disease. Forced expiratory volume in first second (FEV_1) is an important parameter to diagnose as well as to assess the severity of the disease.

ECG changes significantly correlated with low values of FEV_1/FVC ratio. It can be inferred that ECG is a useful bedside screening test to assess the severity of COPD. In view of the very significant negative correlation of FEV_1/FVC% with the increasing incidence of electrocardiographic abnormalities a more aggressive approach to treat the COPD patients can be taken so that the onset of corpulmonale would be delayed as long as possible.

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