

ELECTROCARDIOGRAPHIC AND ECHOCARDIOGRAPHIC CHANGES IN CHRONIC OBSTRUCTIVE PULMONARY DISEASE (COPD) OF DIFFERENT GRADES OF SEVERITYSuma K. R¹, Srinath S², Praveen³**HOW TO CITE THIS ARTICLE:**

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ABSTRACT: BACKGROUND: Chronic obstructive pulmonary disease (COPD) is a major cause of chronic morbidity and mortality throughout the world. Pulmonary hypertension is the major cardiovascular complication of COPD; this is associated with right ventricular dysfunction and cor pulmonale which has a poor prognosis. The detection of right ventricular (RV) hypertrophy in electrocardiography (ECG) has a high specificity but very low sensitivity. 2-D echocardiography can be used to assess right ventricular dimensions and the presence of pulmonary artery hypertension in patients with COPD. **AIMS:** This study was undertaken to observe the electrocardiographic and echocardiographic changes in COPD patients with different grades of severity as assessed clinically and through spirometry and correlate the findings with duration and severity of the disease. **METHODS:** 50 patients with COPD were randomly selected over a period of 2 years. All cases were studied clinically, and underwent chest X-ray, electrocardiography, echocardiography, and spirometry. The severity of the disease was graded according to BTS (British thoracic society) guidelines. Statistical analysis of correlation was done with Pearson's test and Chi square test, and statistical significance was taken a $p < 0.05$. **RESULTS:** Mean age was 59.9 +/- 10.4 years, with male preponderance. Mean duration of disease was 5.71 years, with mean exposure to smoking of 23.2 +/- 3.6 pack years. ECG findings that showed significant correlation with severity of disease were 'p' pulmonale, right axis deviation, right bundle branch block, right ventricular hypertrophy and poor 'R' wave progression. Only right axis deviation increased significantly with duration of disease. Among echocardiographic findings, R.A (right atrial)/R.V dilatation, R.V. failure, pulmonary hypertension and cor pulmonale also showed significant correlation with severity of disease. With respect to duration of disease, R.V. dilatation, pulmonary hypertension and cor pulmonale showed significant increased occurrence with increasing duration of disease. Diagnosis of cor pulmonale clinically was 36%, by ECG was 44% and by echocardiography was 54%. **CONCLUSION:** COPD is more common in males in 5th to 7th decade of life, with a smoking history of more than 20 pack years. Most patients have moderate to severe disease at presentation. The occurrence of ECG and echocardiographic findings increase as severity and duration of disease increases, and echocardiography detects more number of patients with R. V. dysfunction than ECG or clinical methods.

KEYWORDS: COPD, ECG, echocardiography, cor pulmonale.

INTRODUCTION: Chronic obstructive pulmonary disease is a major cause of chronic morbidity and mortality throughout the world. It is the 4th leading cause of death and will be the 5th leading cause of DALYs (Disability adjusted life years) lost world wide in 2020, accounting for enormous socio economic burden.¹ COPD is characterized by slowly progressive airflow obstruction resulting in dyspnea, and exercise limitation and pulmonary arterial hypertension is its major cardiovascular

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complication.² The global initiative for COPD (GOLD) defines COPD as a disease state characterized by airflow limitation that is not fully reversible. It is usually progressive and associated with an abnormal inflammatory response of lungs to noxious particles or gases.¹ Pulmonary hypertension is the major cardiovascular complication of COPD, and occurs in those who have marked airflow limitation (FEV_1 {forced expiratory volume in 1st second} <25% predicted) and also have chronic hypoxemia. This is associated with right ventricular dysfunction and cor pulmonale which has a poor prognosis.^{1,3} Right ventricular dysfunction is common in patients with COPD, and occurs in up to 50% of the patients with moderate to severe COPD, and portends a higher mortality rate. Its recognition and treatment may lead to prolonged survival and improved quality of life.⁴

The detection of RV hypertrophy in ECG has a high specificity but very low sensitivity, a normal ECG does not rule out the presence of pulmonary hypertension in COPD⁵. The ECG abnormalities are usually less pronounced in COPD than other forms of pulmonary hypertension because of the relatively modest degree of pulmonary hypertension and effects of hyperinflation.⁶ 2-D echocardiography can be used to assess right ventricular dimensions and wall thickening and right ventricular volume overload in patients with COPD and also the presence of pulmonary artery hypertension. 2D echocardiography may be technically difficult in patients with COPD because of increase in retrosternal air which transmits sound waves poorly, but an adequate exam can be obtained in 80% of the patients.⁴

This study was undertaken to observe the electrocardiographic and echocardiographic changes in COPD patients with different grades of severity as assessed clinically and through spirometry.

METHODOLOGY: 50 patients with COPD, both male and female, who were admitted in our institution, were randomly selected over a period of 2 years, between January 2011 to December 2013. Patients with other pulmonary pathologies like bronchial asthma, tuberculosis, pneumoconiosis, restrictive lung diseases, and cardiac disease of congenital, rheumatic, ischemic and hypertensive heart diseases were excluded.

All cases were studied clinically, and underwent chest X-ray, electrocardiography, echocardiography, and spirometry. Routine investigations like complete blood count, renal function test, sputum for acid fast bacilli (AFB), and gram stain were also done. The severity of the disease was graded according to British thoracic society (BTS) guidelines.⁷ The findings of ECG (Table 1) and echocardiography (table 2) were recorded. A 12 lead ECG was taken in all patients under study and following points were noted,^{8,9} All patients were subjected to echocardiographic examination in 2D and M mode, to note the presence of pulmonary hypertension, RV hypertrophy, RV dilatation and RV failure.^{7,10}

RESULTS: A total of 50 cases were studied. 42 of these were male and 8 were female. The mean age was 59.94(+/- 10.37) years, range- 40 to 85 years. The maximum incidence of COPD in this study group is among the age group of 50 to 69 years, (50-59=30%, 60-69=36%). 18% were in 70-79yrs, 12% in 40-49yrs, only 4% of the patients were above 80 years. The mean duration of disease was 5.71(+/- 4.98) years, ranging from 2 to 20 years. Maximum number of patients (62%) had symptoms of 1-5 years duration, 28% had 6-10 yrs of symptoms, and patients with more than 10 years of symptoms were only 10%. The mean FEV_1 was 36.06(+/- 12.23) % of predicted, ranging from 17 to

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60% of predicted. 60% of the patients had severe airflow obstruction at the time of presentation, 36% had moderate disease and only 4% had mild disease. The mean duration of tobacco use was 23.2 pack years, ranging from 5 to 45 pack years. Majority of the patients had a tobacco exposure history of 20 to 29 pack years (32%), pts less than 10 pack years history was only 2%. 22% had 10 -19 pack years, 18% had 30-39 pack years, and 10% had >40 pack years of exposure. Majority of the patients with severe disease (70% i.e. 21 out of 30 pts) had history of greater than 20 pack years of tobacco exposure. Among patients with 10-19 pack years, 8% had moderate and 14% had severe disease. 16% of the patients with moderate disease had > 20 pack years of exposure.

Only 2% had <10 pack years of exposure and had moderately severe disease. All patients in this study had history of breathlessness at presentation (100%), 96% of patients had cough with sputum at presentation. 38% of the patients presented with edema. 24% had fever, and 8% had reduced urine output. The most common sign at presentation was tachypnea in 70%, followed by epigastric pulsations in 58%. 36% of the patients had evidence of congestive cardiac failure like, raised JVP (jugular venous pulse), edema and hepatomegaly. 32% of patients had loud p2, suggestive of pulmonary hypertension, 30% had parasternal heave, the clinical evidence of right ventricular hypertrophy, and 26% had cyanosis, clubbing or both which is evidence of hypoxic state, and 2% had CO₂ narcosis.

In chest X-ray, 80% of the patients had features of emphysema. 64% had increased bronchovascular markings suggestive of chronic bronchitis. X-ray evidence of pulmonary hypertension, i.e., prominent pulmonary conus or right descending pulmonary artery >16 mm was present in 30% of patients. Cardiomegaly was seen in 20%.

Analysis of ECG findings showed that 44% of the patients had ECG evidence of right ventricular hypertrophy (RVH) in the study. The most common RVH criteria in these patients was right axis deviation, present in 100% of the patients, followed by R/S in V_{5/6} < 1 in 90%. 48% of the patients in this study had P pulmonale. Low voltage complexes and poor progression of R wave, which are characteristic ECG changes in emphysema were found in 28% and 32% of the patients respectively. 1 patient had complete RBBB (right bundle branch block), and 1 had multiple atrial ectopics. (Table 3). Correlation of ECG findings with severity of the disease (Table 4) showed that the findings of 'p' pulmonale, RAD (Right axis deviation), poor R wave progression, incomplete RBBB and RVH correlate significantly with severity of the disease. (p<0.05).

Correlation of ECG findings with duration of symptoms showed that the most common ECG finding in patients with 1-5 years duration of symptoms was 'p' pulmonale (45%). 35% of the patients in 1-5 years duration group had ECG evidence of RVH. 50% of the patients in 6-10 year group had ECG evidence of RVH. 80% of the patients in >10 year duration group had ECG evidence of RVH. 10% of the patients in 6-10 years group had incomplete RBBB, and 20% in >10 year group had incomplete RBBB. Only right axis deviation had significant correlation with duration of the disease (p<0.05).

Analysis of echocardiographic findings showed that 54% of the patients in this study had echocardiographic evidence of cor pulmonale. 56% of the patients had features of pulmonary hypertension. 48% had features of right ventricular dilatation and 28% had right ventricular hypertrophy. 14% of the patients in this study had echocardiographic features of right ventricular failure. 18% had interventricular septal motion abnormalities and 38% had right atrial dilatation. Correlation of echocardiographic findings with duration of disease showed that 38.7% of the patients

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in the 1-5 year duration group had evidence of cor pulmonale. 71.4% of the patients in 6- 10 years group had evidence of cor pulmonale and in patients with > 10 years of symptoms 100% of them had cor pulmonale. The frequency of occurrence of echocardiographic features of pulmonary hypertension in 1-5, 6-10 and > 10 years groups were 45.2%, 71.4% and 90% respectively. Features of RV failure was present in 9.7%, 21.4% and 20% in 1-5, 6-10 and >10 years groups respectively.

The echocardiographic findings of RV hypertrophy and cor pulmonale correlated significantly with the duration of disease ($p < 0.05$). Correlation of echocardiographic findings with severity of the disease (Table 5) showed that the echocardiographic signs of R.A dilatation, R.V. dilatation, R.V failure, pulmonary hypertension and cor pulmonale correlated significantly with the severity of the disease ($p < 0.05$).

DISCUSSION: In this study, males form 84% of the patients, comparable to other studies^{11,12}, the higher incidence is attributable to smoking. All the females had history of exposure to smoke while cooking with dried cow dung or wood. As with previous studies^{2, 11, 13, 14}, the maximum number of patients were in the age group of 50-70 years, with a mean duration of symptoms of 5.71 years, and 60% of them were having severe disease ($FEV_1 < 40\%$) with majority of them having a mean of 23.2 pack years of tobacco exposure.

Dyspnea and cough with expectoration was the commonest presenting symptom (50%) and most of them had signs of hyperinflation with reduced breath sounds. Signs of RVH and pulmonary hypertension were found in 30% and 32% respectively as in previous studies.^{11,13}

Among ECG findings, 44% of the patients in this study had RVH, which varies widely in different studies depending on the criteria used, and number of patients with cor pulmonale of varying etiologies.^{13,15,16} Among the different RVH criteria, right axis deviation, R/S in $V_5/V_6 < 1$, R/S in $V_1 > 1$ were the commonest ECG changes, which according to different studies were important criteria or RVH.⁸ 48% of the patients had p- pulmonale which according to some can be taken as indirect evidence of RVH.⁸ On correlating the ECG findings with severity of the disease, it was found that, incidence of all ECG findings increased as the severity of the disease increased. Statistical correlation was found with p pulmonale, right axis deviation, incomplete RBBB, and RVH which was significant. (i.e. $p < 0.05$).

Among the ECG findings of emphysema, low voltage complexes and poor progression of 'r' wave, increased in incidence with increasing severity, but not statistically significant. Other studies correlating ECG findings with severity of the disease have also made similar observations. V.K Singh et al also found increasing incidence of 'p' pulmonale, R/S in $V_5/V_6 < 1$, QRS axis $> 90^\circ$ $RV_6 < 5\text{mm}$, with increasing severity of the disease. M.K Tandon also found increasing incidence of 'p' pulmonale, right axis deviation of QRS, and dominant S in $V_{5/6}$ with increasing severity as defined by FEV_1/FVC .^{17,18} On correlating the ECG findings with duration of symptoms, 'p' pulmonale, right axis deviation, and RVH and incomplete RBBB, increased with the duration of the disease, statistical significance was found only with right axis deviation. ($p < 0.05$).^{11,13}

In the analysis of ECHO findings, our study showed 54% of the patients had echocardiographic evidence of cor pulmonale, comprising of R.V. dilatation, R. V. hypertrophy, R. A. dilatation, or evidence of R. V. failure, or inter ventricular septum motion abnormality. Similar incidences were found in some previous studies^{19,20}. On correlating the echocardiographic findings with severity of the disease, the incidence of all the findings increased as the severity increased.

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All the findings had statistically significant correlation with severity, except R.V. hypertrophy, and inter ventricular wall motion abnormality, probably because of relatively lesser number of patients in moderate group, and variation in measurement of R.V wall thickness due to the presence of trabaculae, and difficulty in differentiating it from surrounding structures. Studies by Higham et al showed pulmonary hypertension in 43% in moderate and 68% in severe group, and a study by N.K. Gupta, Rithesh Kumar Agarwal showed 54.5% in moderate, 60% in severe and 100% in very severe groups, as compared to 28% and 73% in our study, the higher occurrence in severe group is probably due to higher percentage of our patients were in severe group.^{2,21} On correlating echocardiographic findings with duration of disease, statistically significant correlation was found R.V dilatation, pulmonary hypertension and corpulmonale.

In this study, a diagnosis of corpulmonale could be made in 36% of patients by clinical methods, 44% by electrocardiographic methods and 54% by echocardiographic methods. This shows that echocardiography can detect more number of patients with corpulmonale in COPD and is similar to previous studies,^{19,22,23} This is because, clinical signs of R.V dysfunction are difficult to detect in COPD due to lung hyperinflation and posterior rotation of heart. ECG criteria for detecting R.V hypertrophy have a reasonably high specificity but relatively low sensitivity. Echocardiography also has its difficulties in COPD patients due to over inflation of lungs which reduces the probability of getting reliable measurements.²⁰ But most studies report that adequate examination can be obtained in more than 70% of the patients. Many studies have proved that echocardiography is more sensitive than electrocardiography in detecting R.V dysfunction in COPD.^{23,24} Therefore early and periodic echocardiography in COPD patients can help in detection of pulmonary hypertension and cor pulmonale in early stages thereby, ensuring adequate treatment thus reducing morbidity in COPD.

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1.	P wave changes	
	-p pulmonale	p>2.5 mm
2.	Criteria for RVH 6*	
	-right axis deviation	>110°
	-r/s ratio in lead v1	>1
	-r wave in v1	>7mm
	-s wave in v1	<2mm
	Qr pattern in v1	
	R in v1+s in v5 or v6	>10.5mm
	r/s ratio in v5 or v6	<1
	Rsr' in v1 with r	>10mm
3.	Low voltage complexes	
	QRS in limb leads	<5mm
	QRS in chest leads	<15 mm
4.	Poor progression of r waves	
5.	Incomplete RBBB	
	rsR'/rSr in v1 with QRS	<0.12sec
6.	Arrhythmias	
	-atrial/ventricular ectopics	
	-atrial flutter/fibrillation	
	-ventricular tachycardia	

Table 1. ECG Findings

*presence of any of the above criteria is suggestive, but presence of 2 or more criteria is diagnostic.

1.	Pulmonary artery diameter	
2.	Evidence of pulmonary hypertension on M mode examination of pulmonary valve	'-a' wave -EF slope -Midsystolic notch, flutter
3.	RV hypertrophy	-Thickness of anterior wall & septum>6mm
4.	RV dilatation	-Diastolic dimation>25mm
5.	RA dilatation	
6.	RV failure	-Tricuspid regurgitation -RV wall motion abnormalities -Dilatation of IVC and hepatic vein
7.	Corpulmonale	-RV dilatation -RVH -RV failure

Table 2: Echocardiographic findings

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RVH criteria	No. of cases	Percentage (%)
Right axis deviation	26	52
R/S in V ₁ > 1	15	30
R > 7mm in V ₁	8	16
S < 2mm in V ₁	13	26
qR in V ₁	5	10
R/S in V ₅ /V ₆ < 1	20	40
RV ₁ +S V _{5/6} > 10.5mm	13	26
rsR in V ₁ with R > 10mm	2	4
Incomplete RBBB	4	8
RVH	22	44

Table 3: Frequency of appearance of each RVH criteria

ECG findings	Mild (n=2)		Mod (n=18)		Sev (n=30)		'r'	'p'
	No	%	No	%	no	%		
'p' pulmonale			7	38.8	17	56.7	-0.978	<0.001
Low voltage complex	1	50	3	16.7	10	33.3	0.502	>0.05
Right axis deviation			6	3.3	20	66.7	-0.99	<0.001
Poor R wave progression			5	27.7	11	36.7	-0.95	<0.001
Incomplete RBBB					4	13.3	-0.86	<0.001
RVH			6	33.3	16	53.3	-0.87	<0.001

Table 4: Correlation of ECG findings with severity of disease

ECHO Findings	Mild (n=2)		Moderate (n=18)		Severe (n=30)		'χ ² '	'p'
	no	%	No	%	no	%		
R.A dilatation	1	50	3	16.7	15	50	4.584	0.032
R.V dilatation			2	11	22	73.3	19.284	0.000
R.V hypertrophy			3	16.7	11	36.7	2.794	0.095
R.V failure					7	23.3	5.426	0.020
IVS motion abnormality			1	5.6	8	26.7	3.817	0.051
Pulmonary hypertension	1	50	5	27.8	22	73.3	9.145	0.002
Cor pulmonale			4	22.2	23	76.7	15.513	0.000

Table 5: Correlation of echocardiographic findings with severity of the disease

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