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A study on the severity of right ventricular dysfunction in correlation with the severity of Lung dysfunction in Chronic Obstructive Pulmonary Disease patients - COPD

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Abstract

Background: Chronic Obstructive Pulmonary Disease (COPD) is characterized by airflow limitation that is not fully reversible. COPD is a powerful and independent risk factor for cardiovascular morbidity and mortality which includes right ventricular (RV) dysfunction and cor pulmonale secondary to pulmonary arterial hypertension (PAH), coronary artery disease (CAD), and cardiac arrhythmias. The aim of this study is to assess RV dysfunction by utilizing RV parameters obtained by clinical methods, electrocardiography (ECG), and echocardiography and to correlate with the severity of airflow limitation in COPD patients.

Methods: Analysis of 100 cases of COPD admitted to Government General Hospital, Kakinada during the period of October 2012 to May 2013.

Results: COPD is more common in males than females in the ratio of 5.25:1. Majority of patients (46%) had a mean of 8.4 years of smoking history. Most common symptoms and signs observed are dyspnea (100%), cough (96%) and tachypnoea. Signs suggesting cor pulmonale are parasternal heave, loud P2 and elevated JVP. Radiological study revealed emphysema in 52% and prominent right descending pulmonary artery suggesting PAH in 25%. ECG findings are suggestive of RV dysfunction i.e., P-pulmonale, Right axis deviation (RAD), incomplete RBBB and RVH. Echocardiographic signs of RV dysfunction observed are PAH, cor pulmonale and RVSD which are correlated with the severity of the disease ($p < 0.05$). PAH, was observed in 40%. Cor pulmonale was observed in 45% of patients having PAH. The frequencies of cor pulmonale in patients with mild, moderate and severe PAH were 10%, 73.3%, and 100%, respectively. 45% of COPD patients had normal echocardiographic findings.

Conclusions: Echocardiographic examination is reliable in following COPD patients with PAH instead of repeated cardiac catheterization. The incidence of RV dysfunction is more common as the severity of COPD increases and there is a significant correlation between the degree of air flow limitation (FEV₁) and RV dysfunction.

Keywords: Chronic Obstructive Pulmonary Disease, ECG, RV, CAD

INTRODUCTION

Chronic Obstructive Pulmonary Disease (COPD) is a disease state characterized by airflow limitation that is not fully reversible, it includes chronic bronchitis, emphysema and small airway disease.

Diagnosis of COPD dates back to Hippocrates (460-377 BC), the father of medicine, described an old man suffering from breathlessness associated with catarrh and cough.

COPD is currently the 4th leading cause of death in the world and further increases in its prevalence and mortality can be predicted in the coming decades. COPD accounts for a substantial number of visits to general

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physician, emergency department, hospital admissions, and also a cause for frequent absence from work. In 1990 COPD is the 12th leading cause of DALY's (Disability Adjusted Life Years) lost world over and according to projections, COPD will be the 7th leading cause of DALYs lost and also fourth leading cause of death world-wide in 2030, thus accounting for enormous social and economic burden world-wide [1].

The cardiovascular sequelae of chronic obstructive pulmonary disease (COPD) have been recognized for decades. COPD is a powerful and independent risk factor for cardiovascular morbidity and mortality [2]. The spectrum of cardiovascular disease includes right ventricular (RV) dysfunction secondary to pulmonary arterial hypertension (PAH), coronary artery disease (CAD), and cardiac arrhythmias.

RV dysfunction is common in patients with COPD particularly in those with low oxygen saturation. It is essential to assess the extent of impairment of pulmonary function and the pulmonary arterial hypertension (PAH) caused by the same to establish the long-term prognosis of the disease. PAH affects the function of right ventricle leading to Cor pulmonale and once developed the patient with Cor pulmonale has poor prognosis. So, the early recognition of RV dysfunction and PAH may help in treatment and prolonging the survival of the patients with Cor pulmonale.

There are various non-invasive methods to determine the respiratory function and the extent of reversibility of the same. However, it is difficult by non-invasive methods to accurately determine the PAH and RV dysfunction caused by the same. Various attempts have been made to assess the same by clinical methods, electrocardiography, ro-entegenology and echocardiography.

COPD is "a disease state characterized by airflow limitation that is not fully reversible. The airflow limitation is usually both progressive and associated with an abnormal inflammatory response of the lungs to noxious particles or gases" [1].

The aim of this study is to the clinical profile of patients and to evaluate assess right ventricular dysfunction by utilizing right ventricular parameters obtained by clinical methods, electrocardiography, and echocardiography and to correlate with the severity of airflow limitation in COPD patients.

MATERIALS AND METHODS

A Prospective study is conducted on 100 patients admitted with signs and symptoms suggestive of COPD in Medical and Chest wards of Government General Hospital, Kakinada from November 2011 to May 2013. Patients were diagnosed clinically as having COPD with subsequent confirmation by spirometry. The patients

with Asthma, Bronchiectasis, Tuberculosis, and Pneumoconiosis, restrictive lung disease like kyphoscoliosis, Rheumatic, Congenital, Ischemic heart disease and hypertension were excluded from the present study.

All the 100 randomly selected COPD patients were studied clinically radiologically, electrocardiographically, echocardiographically and also with pulmonary function tests. Patients were investigated when their condition stabilized.

Before the commencement of the study, permission was obtained from Ethics committee, Rangaraya Medical College, Kakinada. All enrolled patients were informed about nature of the study and their rights to refuse. The informed written consent was taken before including them in the study.

Patients were asked about the duration of symptoms like breathlessness, cough, amount, nature and diurnal variation of expectoration and severity of breathlessness to clinically categorize them into predominant chronic bronchitis and predominant emphysema. Patients were also asked about history of pedal edema, distension of abdomen, puffiness of face, right hypochondriac pain, to know whether the patient had developed R.V. dysfunction.

A detailed clinical examination was carried out as shown in the proforma. Pulmonary function tests were done in all and patients were graded according to the severity of COPD with guidelines given by Global initiative for Obstructive Lung Disease (GOLD). Chest X ray, twelve lead electrocardiogram, and 2 D Echo were done to assess the severity of right ventricular dysfunction.

Various observations in the study were analyzed and the severity of COPD was correlated with the ECG and Echocardiographic features of right ventricular dysfunction. The statistical software SPSS 20.0 was used for the analysis of data. Microsoft word and Excel have been used to generate graphs, tables etc.

OBSERVATIONS AND RESULTS

Age and Sex Distribution

The maximum number of COPD patients (65%) in this study were in the 6th and 7th decades, with 36% patients in the 7th decade (61-70 years age group) and 29% in 6th (51-60 years age group). All the patients in the present study were more than 40 years of age with only 20% beyond 70 years. (Table 1).

Mean age of presentation in the present study is 61.63 yrs.

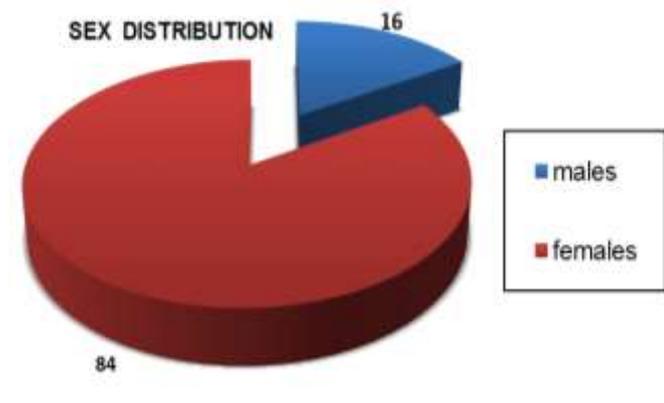
Majority of patients (46%) in the study had symptoms for 6–10 years at presentation. Mean duration of

symptoms is 8.4 yrs. In the present study, majority of the patients (77%) had history of smoking. Of the 77 only 3 of them were females remaining are males. The mean duration of smoking observed in the study is 22.62 pack years with a range of 8 to 44 pack years. Majority of smokers (59.7%) had history of smoking more than 20 pack years.

Table 1: Age and Sex Distribution

AGE (YEARS)	FEMALES (n = %)	MALES (n = %)	TOTAL (n = %)
41-50	4	11	15
51-60	8	21	29
61-70	3	33	36
>70	1	19	20
TOTAL	16	84	100

In the present study majority of the cases are males constituting 84%. Male : female ratio was 5.25 : 1 (Figure-1).



Staging and severity of the disease:

In the present 40% patients had mild disease, 30% had moderate, severe and very severe disease were observed in 15% each. The mean FEV1 observed was 61.1%. (Table-2).

Table-2. Staging and severity of the disease

COPD stage	Severity	Fev ₁	No Of Cases		Total
			Male	Female	
Stage I	Mild	≥ 80%	26	14	40
Stage II	Moderate	50 – 80%	28	2	30
Stage III	Severe	30 – 50%	15	–	15
Stage IV	Very Severe	≤ 30%	15	–	15

In mild disease mean FEV1 observed was 86.87%, in moderate 58.96%, severe 35% and very severe 22.73%. Analysis showed 45% of patients with mild disease, 10% with moderate, 6.7% each with severe and very severe COPD are nonsmokers. (Figure-2).

Symptoms at presentation

All the patients in the study presented with history of shortness of breath. 96% had cough, 14% had fever, 10% presented with swelling of feet and 4% had oliguria (Figure-3).

Signs at presentation:

The most common sign at presentation is tachypnoea in 100%. Other common signs observed are barrel chest

Figure-2. Correlation of smoking with Disease Severity

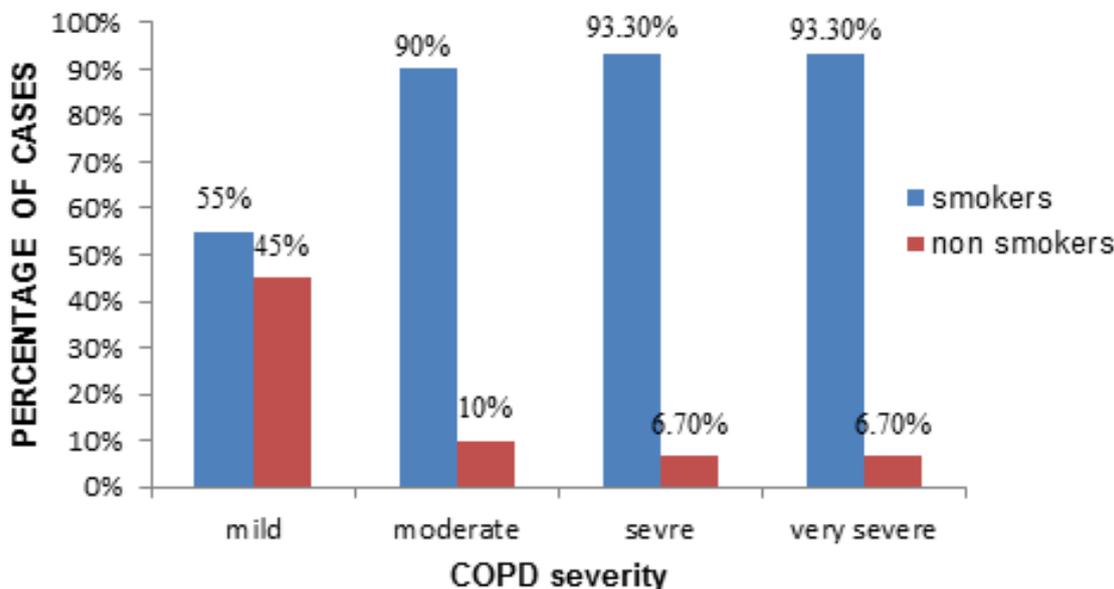
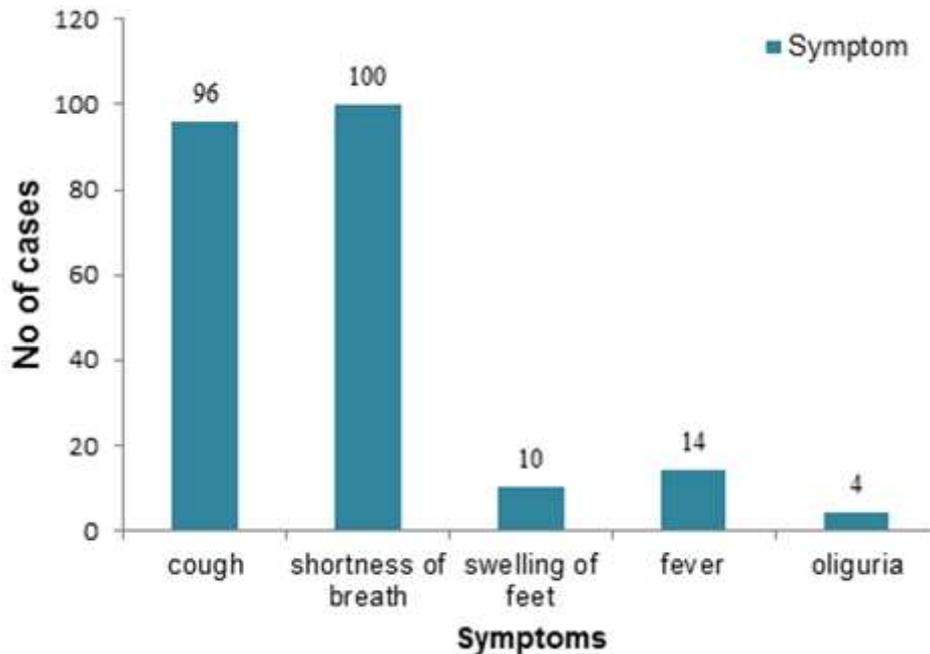


Figure-3. Symptoms at presentation



(65%), wheeze was observed in 61% of the patients. 30% of the patients had loud P₂ suggestive of pulmonary arterial hypertension. 25% of the patients had parasternal heave, the clinical evidence of right ventricular hypertrophy. 10% of the patients had evidence of congestive cardiac failure like raised JVP, pedal edema, tender hepatomegaly. 8% of the patients had cyanosis which is evidence of a hypoxic state (Table 3).

Table-3. Signs at presentation

Sign	No Of Cases	Percentage
Tachypnoea	100	100
Wheeze	61	61
Cyanosis	8	8
Barrel Chest	65	65
Parasternal Heave	25	25
Loud P ₂	30	30
Elevated JVP	10	10

Chest X- ray findings:

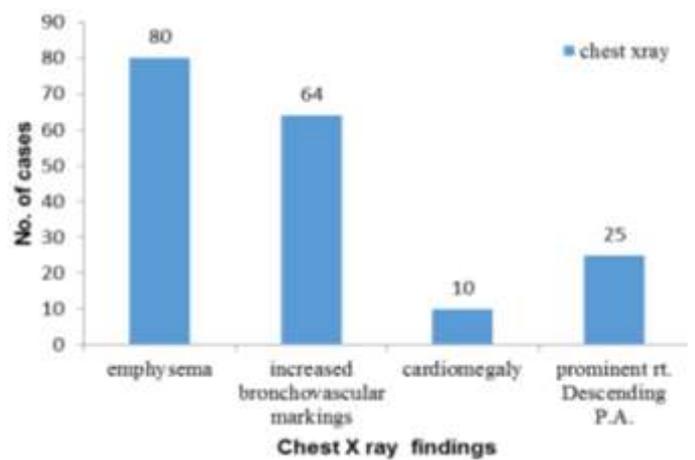
52% of the patients had X-ray feature of emphysema. 12% of the patients had increased broncho-vascular markings suggestive of chronic bronchitis. X-ray evidence of pulmonary hypertension i.e. prominent pulmonary conus/prominent right descending pulmonary artery (> 16 mm) was present in 25% of the patients. Cardiomegaly on X-ray was present in 10% (Figure-4).

Electrocardiographic Findings:

In this study 17% of patients had ECG evidence of RVH. P-pulmonale was observed in 25% of patients in the present study. Right Axis Deviation (RAD) was present in 16% of patients in the study and in 94.1% of

patients with RVH. Incomplete RBBB was observed in 5% of the patient's (Figure-5).

Figure-4. Chest X-Ray findings



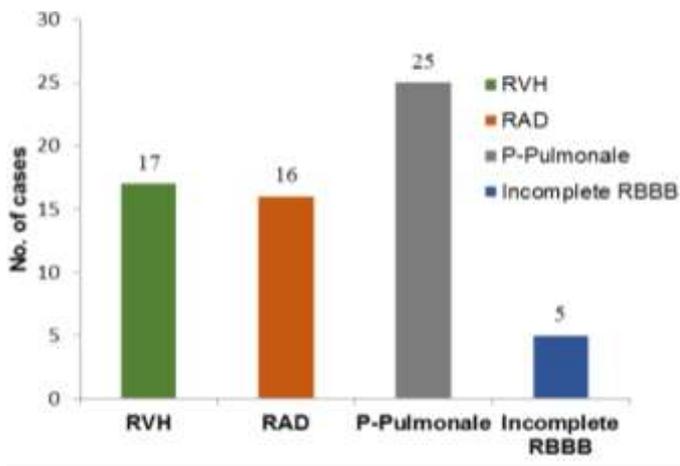
Electrocardiographic Finding (Figure-5)

In the STAGE I COPD only 7.5% had ECG changes where as in the STAGE IV category, 73.3% of the patients had some ECG changes.

RVH was observed in 7.5% of STAGE I patients while in case of STAGE II, III and IV it was seen in 10%, 26.7% and 46.7% respectively. P- Pulmonale was observed in only 7.5% of STAGE I patients while in case of STAGE II, III and IV it was seen in 23.3%, 40% and 60% respectively.

RAD was observed in 5% of STAGE I patients while in case of STAGE II, III and IV it was seen in 23.3%, 40% and 60% respectively.

Figure-5. Electrocardiographic Findings

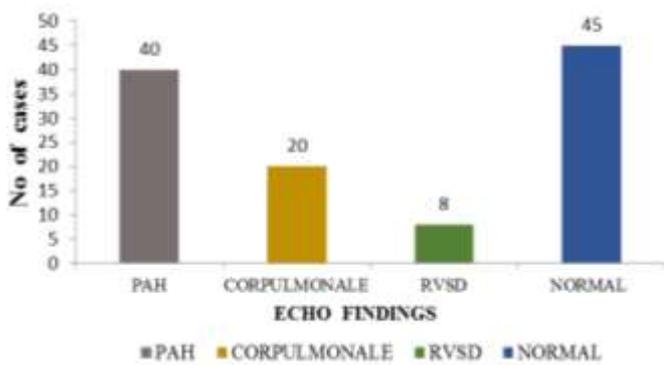


Incomplete RBBB was observed only in STAGE III (6.7%) and IV (26.7%) patients. P-pulmonale, RAD, Incomplete RBBB and RVH correlated significantly.

Echocardiographic Findings:

Pulmonary arterial hypertension (PAH), which is defined as pulmonary arterial systolic pressure (PASP) >30 mmHg was observed in 40% cases. Corpulmonale was observed in 20 out of 40 cases having PAH (50%). Right ventricular systolic dysfunction (RVSD) was observed in 8 cases with PAH (20%). 45% of the COPD patients had normal 2D ECHO (Figure-6).

Figure-6. Echocardiographic Findings



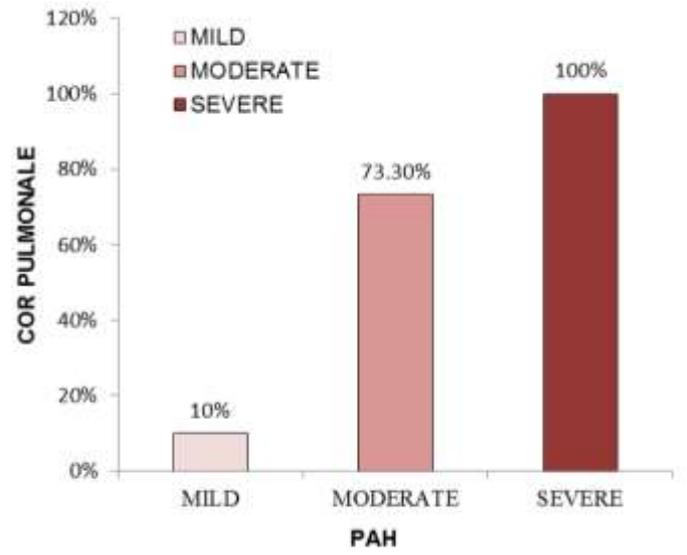
The frequencies of corpulmonale in patients with mild, moderate, and severe PAH were 10%, 73.3%, and 100%, respectively; so we can see a good correlation between severity of PAH and the development of corpulmonale (Figure-7).

DISCUSSION

Chronic obstructive pulmonary disease is one of the leading cause of chronic morbidity and mortality worldwide. This prospective study of COPD consisted of 100 patients admitted to Government General Hospital attached to Rangaraya Medical College, Kakinada, East

Godavari District, Andhra Pradesh. All cases met inclusion and exclusion criteria.

Figure-7. Correlating PAH and RVH



In this study, electrocardiographic and echocardiographic changes of RV dysfunction seen in COPD patients were studied and correlated to the severity of the disease. The maximum number of COPD patients (65/100) in this study were in the age group of 51-70 years with mean age 61.63 years, which is similar to previous studies [3-5]. Patients between 50-70 yrs form the maximum number of patients admitted, mainly because of the longer duration of tobacco exposure and repeated respiratory tract infections, which would have compromised their quality of life.

In this study the male:female ratio was 5.25: 1. Males form 84% of the study subjects. This higher incidence of COPD in males can be attributed to smoking habits. In our study 3 of the 16 females were smokers but all of them had history of indoor air pollution in the form of cooking with dried cow dung or dried wood fuel. Number of males in the study by J.C Benergea6 is 80%, which is similar to present study (84%).

In this study most of the patients 46% gave history of symptoms of 6-10 years duration, with a mean duration of dyspnoea and cough of 8.4 years. This is similar to the study conducted by Gupta et al4 in which the mean duration of symptoms was 8.9+4.9 years.

In the present study very severe COPD (STAGE IV) was present in 15% of the cases and mean FEV1 was 22.75%. Severe disease (STAGE III) was observed in 15% with a mean FEV1 of 35%. Mild disease was observed in 40% and moderate in 30% of the patients. Majority of the cases with mild and moderate COPD were admitted for exacerbations. Comparing with other studies of Gupta. N. K et al [7], the present study had similar findings.

In the present study majority of the patients (77%) had history of smoking. The mean duration of smoking observed in the study is 22.62 pack years with a range of 8 to 44 pack years. Majority of patients (59.7%) had history of smoking more than 20 pack years. In the present study 85.7% of patients each in STAGE III, STAGE IV and 70.4% in STAGE III were having a smoking history of more than 20 pack years, where as in case of STAGE I 86.3% of patients had history of smoking less than 20 pack years. ($p < 0.001$).

From the above findings it is clear that duration of smoking has a significant correlation with the severity of disease. In the study by Gupta and Khastgir⁴ mean of 26.4 pack years of smoking history was found, which is similar to the present study.

Almost all the patients had breathlessness and cough with sputum on presentation. Breathlessness is the symptom that commonly causes the patient to seek medical attention, and is usually the most disabling of these symptoms. Patients often date the onset of their illness to an acute exacerbation of cough with sputum production, which leaves them with a degree of chronic breathlessness. Close questioning usually reveals the presence of a "smokers cough" (which is usually disregarded by the patient), with scanty mucoid sputum, mainly in the morning for many years, shortness of breath, Pedal edema, Reduced urine output. Similar findings were observed with study of J. C. Banerjee [6].

All the patients in the present study had tachypnea on presentation. Most of them had signs of hyperinflation, and also diminished breath sounds with prolonged expiratory phase. Clinical signs of right ventricular hypertrophy (parasternal heave) was present in 25% (25/100) of the patients and pulmonary hypertension (loud P2) in 30% (30/100) of the patients. The higher incidence of signs of RVH, pulmonary hypertension and CHF in the study by Gupta & Khastgir [4] can be explained by the fact that their study included nearly 80% of the patients with severe disease and with cardiovascular complications in majority of the cases.

Majority of the patients in the present study had evidence of emphysema i.e. signs of hyperinflation like low flat diaphragm, hypertranslucency etc. The incidence of chest X ray signs correlated with the study of Gupta & Khastgir [4]. The higher incidence of cardiomegaly and prominent right descending pulmonary artery in their study is probably due to inclusion of majority of severe cases of COPD in their study.

In this study 30% (30/100) of the patients had ECG evidence of RVH, with criteria used as given by Braunwald. The incidence of RVH by ECG varies in different studies, depending on the number of patients in copulmonale in the study, and the criteria used by the authors.

The Table-4 shows the incidence of RVH in different studies. From this study, it is clear that the incidence of RVH varies widely in different studies. Our findings correlate with the findings of Caird and Wilcken [8].

Table-4. Incidence of RVH in different studies

Study	Incidence (%)
Caird and Wilcken ⁸	16
Padmavathi & Raizada ⁹	59.7
Gupta & Khastgir ⁴	50
Present study	17

It was present in 16% (16/100) of the patients in the present study and in 94.1% (16/17) of the patients with RVH. According to Murphy & Hutcheson¹⁰, right axis deviation is one of the most reliable criteria of RVH, and is more common in patients with RVH secondary to COPD than in those with RVH secondary to congenital heart disease and has a specificity of 95%. Comparing with other studies (4,10,11,12). Our findings are in agreement with the above studies.

P-Pulmonale has been used as an indirect evidence of right ventricular hypertrophy by various authors. The findings in the present study had similar incidence as to the other studies [10, 13, 14, 15].

In the present study, the incidence of all the ECG findings, increased as the severity of the disease (as measured by FEV1 and graded according to GOLD criteria) increased.

Statistical correlation, was found with 'p' pulmonale, RAD, incomplete RBBB and RVH, which was also significant (i.e. $p < 0.05$). This means that the increase in incidence of the above ECG findings, with increasing severity (decreasing FEV1) was statistically significant. Other studies correlating the ECG findings with severity of the disease have also made similar observations, and also have given different explanations for their observation.

Caird and Wilcken [8] observed that 'p' pulmonale and evidence of RVH are much more frequent when FEV1 falls below 45% of normal than above it.

A. G. Chappell [17,22] also studied 112 patients, dividing them into 2 groups, one with FEV1 < 1200 ml and other with > 1200 ml and found that, R. V. hypertrophy, 'p' pulmonale and vertical 'p' axis occurred more frequently in patients with widespread emphysema than in the other group.

In cases with little or no airway obstruction, these ECG changes are due to positional changes of heart, while in those with severe airway obstruction, both positional changes and hypertrophy or dilation, or both, of the right side of heart are likely to be responsible for

the high incidence of these electrocardiographic features.

In the present study, 40% (40/100) of the patients had echocardiographic evidence of pulmonary hypertension. In the present study, 20% (20/100) 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 (IVS) motion abnormality.

Table-5. Incidence of the individual findings in this study and comparing with a previous study

ECHO finding	Gupta NK, 2011 ⁷ (%)	Present study (%)
PAH	42.5	40
COR PULMONALE	17.5	20
RVSD	7.5	8
NORMAL STUDY	50	45

From this study, it is clear that the findings correlates well with the findings in the study by Gupta NK, [7,23].

In the present study, the incidence of all the echocardiographic findings increased as the severity of the disease increased, i.e. maximum incidence was found in the most severely affected group of patients.

All the findings had statistically significant correlation with severity. ($p < 0.05$)

- PAH was observed in 15% of STAGE I patients where as in STAGE II, III, and IV it is seen in 43.3%, 66.6% and 80% respectively.
- Cor pulmonale was present in 66.6% of STAGE IV patients whereas only 2.5% of STAGE I had similar finding.
- RVSD was observed in 40% of STAGE IV whereas the same is observed in 3.3% of STAGE II and none in STAGE I.

Table-6. Comparison of pulmonary hypertension in correlation with COPD severity.

COPD SEVERITY	Gupta NK, 2011 ⁷ (%)	Present study (%)
STAGE I	16.7	15
STAGE II	54.6	43.3
STAGE III	60	66.6
STAGE IV	83.3	80

The frequencies of cor pulmonale in patients with mild, moderate, and severe PAH were 10%, 73.3%, and 100%, respectively, so we can see a good co-relation between severity of PAH and the development of cor pulmonale. Comparing with Gupta NK, 2011 and other studies of ROMAIN A et al [17-20] similar findings were observed regarding the frequency of cor pulmonale mild disease was 10%, moderate 75%, severe 100%

CONCLUSIONS

Analysis of 100 cases of COPD admitted to Government General Hospital, Kakinada during the period of October 2012 to May 2013 yielded the following results :

COPD is more is commonly observed in 6th and 7th decades, more in males than females in the ratio of 5.25:1. Smoking is the most common risk factor observed in 77% cases.

Majority of the patients (46%) had 6-10 years of symptoms prior to presentation with a mean of 8.4 years. Most common symptoms observed are shortness of breath (100%) and cough (96%). Tachypnoea was present in all the cases, common signs suggesting cor pulmonale observed are parasternal heave, loud P2 and elevated JVP. Radiological study revealed emphysema in 52%. Prominent right descending pulmonary artery suggesting pulmonary arterial hypertension was seen in 25%. In ECG the findings suggestive of RV dysfunction i.e., P-pulmonale, RAD, incomplete RBBB and RVH correlated significantly with severity of disease. Echocardiographic signs of RV dysfunction observed are PAH, cor pulmonale and RVSD. The echocardiographic signs of PAH, Cor pulmonale, RVSD correlated with the severity of the disease ($p < 0.05$). 45% of the COPD patients had normal echocardiographic findings. ECG and echocardiography are very useful in detecting R.V. dysfunction in COPD. Echocardiographic examination is reliable in following COPD patients with PAH instead of repeated cardiac catheterization. The incidence of RV dysfunction is more common as the severity of COPD increases and there is a significant correlation between the degree of air flow limitation (as measured by FEV1) and RV dysfunction.

Competing interests

The authors have declared that no competing interests exist.

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