Original Article

Chronic obstructive pulmonary disease and cardiac comorbidities: A cross-sectional study

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ABSTRACT

Introduction: Chronic obstructive pulmonary disease (COPD) is a global health issue with cigarette smoking being an important risk factor. COPD affects pulmonary blood vessels, right ventricle, as well as left ventricle leading to the development of pulmonary hypertension (PH), cor-pulmonale (COR-P), right and left ventricular dysfunction. Echocardiography provides a rapid, noninvasive, portable, and accurate method to evaluate cardiac functions. Early diagnoses and intervention for cardiac comorbidities would reduce mortalities. **Materials and Methods:** A cross-sectional study. Total 50 patients of moderate to severe COPD according to GOLD guidelines were taken from Department of Respiratory Medicine, Smt. B. K. Shah Medical Institute and Research Centre, Vadodara. All patients underwent investigations such as chest X-ray PA view, ECG, and spirometry followed by two-dimensional echocardiography. **Results:** We investigated 49 males and 1 female patients ranging from 35 to 80 years of age. Twenty-nine individuals were of moderate COPD and twenty-one of severe COPD. Of these cases 29 had left ventricular diastolic dysfunction (LVDD) changes, 24 were diagnosed with PH and 16 had changes of COR-P. The study showed the linear relation between the severity of LVDD, PH, and COR-P with the severity of COPD. **Conclusion:** Our study put emphasis on early cardiac screening of all COPD patients which will be helpful in the assessment of the prognosis and will further assist in identifying the individuals likely to suffer increase morbidity and mortality.

KEY WORDS: Chronic obstructive pulmonary disease, cor-pulmonale, echocardiography, left ventricular diastolic dysfunction

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INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a global health issue with smoking being the most important risk factor. By 2020, it will be the third most leading cause of mortality and fifth leading cause of morbidity in the world.[1,2] There is a crude estimate of about 30 million people in India suffering from COPD, and the death rate is among the highest in the world, data suggests that about 556,000, i.e. (>20%) of total 2,748,000 die in India annually.[3,4]

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COPD is characterized by chronic airflow limitation and a range of pathological changes in the lungs. In addition, COPD presents significant extrapulmonary effects and is associated with important comorbidities that may contribute to the disease severity. Chronic airflow limitation is associated with an abnormal inflammatory response of the lungs to noxious particles or gases, particularly cigarette smoke.[5]

COPD affects pulmonary blood vessels, right ventricle, as well as left ventricle leading to the development of

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pulmonary hypertension (PH), cor-pulmonale (COR-P), right ventricular dysfunction, and left ventricular dysfunction. Ischemic heart disease is one of the main causes of mortality in COPD.[6] Co-existence of both diseases is very common and has diagnostic, therapeutic, and prognostic implications.[7,8] Chronic bronchitis alone increases the risk of coronary deaths by 50%. Reduced ratio of forced expiratory volume in 1 s (FEV1) to forced vital capacity (FVC) is also an independent risk factor for coronary events, increasing the risk by 30%. With every 10% decrease in FEV1, all-cause mortality increases by 14% and an increase in cardiovascular mortality by 28%.[9] In more advanced COPD, cardiovascular diseases account for 20–25% of all deaths.[10]

Left ventricular diastolic dysfunction (LVDD) is defined as the inability of the ventricle to fill to a normal end-diastolic volume, both during exercise as well as at rest, while left atrial pressure does not exceed 12 mmHg.[11-13] LVDD is a common co-phenomenon in COPD.[14,15] Abnormal left ventricular function is seen in COPD due to many factors such as hypoxia, acidosis, ventricular interdependence, lung hyperinflation, and distension.

Left ventricular systolic dysfunction (LVSD) is a disorder characterized by failure of the left ventricle to produce adequate output despite an increase in distending pressure and end-diastolic volume.

PH is an increase of blood pressure in the pulmonary artery, pulmonary vein, or pulmonary capillaries, together known as the lung vasculature.

PH is defined as systolic pulmonary artery pressure (sPAP) >30 mmHg and it is classified into mild, moderate, and severe grades as sPAP 30–50 mmHg, sPAP 50–70 mmHg, and sPAP >70 mmHg, respectively.[16,17]

COR-P is defined as an alteration in the structure and function of the right ventricle caused by a primary disorder of the respiratory system. PH is the common link between lung dysfunction and the heart in COR-P. COR-P can develop due to various cardiopulmonary diseases. COR-P usually has a slow and chronic progression, but acute onset and life-threatening complications can occur.[18]

Echocardiography provides a rapid, noninvasive portable, and almost accurate method to evaluate the right ventricle function, right ventricular filling pressure, tricuspid regurgitation, left ventricular function, and valvular functions.[19] It has been studied that echocardiography measured pulmonary arterial pressure closely correlates with pressure measured by right heart catheterization.[20,21]

This study was undertaken to evaluate cardiac function with echocardiography in COPD patients which may further help to assess the prognosis and assist in identifying the individuals likely to suffer increase morbidity and mortality.

MATERIALS AND METHODOLOGY

This was a cross-sectional study. Consecutive 50 diagnosed moderate to severe COPD patients according to GOLD guideline (postbronchodilator FEV1/FVC ratio <70% predicted, moderate COPD [50% ≤FEV1 <80% predicted], severe COPD [FEV1 <50% predicted]), respectively have been taken for the study at Dhiraj Hospital, Smt. B. K. Shah Medical Institute and Research Centre, Piparia, Vadodara. The subject included between the age of 35–80 years with informed and written consent.

The patients which were not made as a part of the study were the one with, known diagnosis of respiratory problems such as pneumonia, tuberculosis, bronchial asthma, interstitial lung disease, carcinoma lungs, and other lung pathologies.

The other category of patients who were excluded had a history of cardiac diseases like ischemic heart disease, rheumatic heart disease, valvular heart diseases, congenital heart disease, and others. Patients who were immune compromised and suffering from (HIV, diabetes mellitus, carcinoma, systemic lupus erythematosus, and other immunosuppressive diseases) were also considered as exclusion criteria for the study.

All the patients selected were asked for the detailed history of respiratory as well as cardiovascular symptoms and were clinically examined for the signs of ventricular hypertrophy, cardiomegaly, PH and/or heart failure.

Patients were investigated for routine investigations such as complete blood count, renal functions, randomized blood sugar and further for a chest X-ray, electrocardiography, and two-dimensional (2D)-echocardiography.

2D-echocardiography was done by a VIVID 7 model of GE healthcare system with a multi-frequency probe with a range of 2–4.3 MHz both 2D and M-mode studies were done. Echo was done to review the pericardium, valvular anatomy and function, both sided chamber size and cardiac function.

Pulmonary hypertension

It was defined in this study as sPAP ≥30 mmHg.[16] This value was chosen according to the definition of PH. PH was classified into mild, moderate, and severe category as sPAP 30–50, 50–70, >70 mmHg, respectively (using Chemla formula, mean pulmonary arterial pressure (MPAP) =0.61 PASP +2 mmHg and putting value of 25–35, 35–45, and >45 mmHg of MPAP for mild, moderate, and severe PH, respectively).[17]

Measures of right ventricular functions

Right ventricle dimension was measured by M-mode echocardiography, and right ventricular dilation or COR-P was said to be present when it exceeded the normal range

of 0.9–2.6 cm. Right ventricle contractility was also noted, and right ventricular systolic dysfunction was said to be present when it was hypokinetic.

Measures of left ventricular functions

E/A = diastolic filling of left ventricles usually classified initially on the basis of the peak mitral flow velocity of the early rapid filling wave (E), peak velocity of the late filling wave caused by atrial contraction (A). In normal subjects, LV elastic recoil is vigorous because of normal myocardial relaxation, therefore, more filling is completed during early diastolic, so LVDD is said to be present when E/A is <1.3 (age group 45–49 years), <1.2 (age group 50–59 years), <1.0 (age group 60–69 years), and <0.8 (age group ≥70 years).[22]

Statistical analysis: The descriptive statistical analysis of data has been done. The age and sex distribution of all patients, their body mass index (BMI), severity of COPD, echocardiography findings, the frequency of COR-P and its relation to COPD has been represented graphically.

Correlation between the cardiac parameters on echocardiography findings and pulmonary parameters on spirometry findings have been done to find out the relation and to estimate the risk of morbidity.

The mean and standard deviation (SD) of FEV1 and PH of all the patients has been calculated along with Pearson correlation value.

RESULTS

We investigated 49 males and 1 female patient in the age group of 35–80 years. Mean BMI was 19.59 kg/m^2. Out of 50 patients, 24 (48%) patients were underweight. The mean pack years for smoking were 31.33. On the basis of severity, the study showed 58% of moderate COPD and 42% of severe COPD patients. Mean ± SD calculated for FEV1 was 49.05 ± 14.61.

The most common finding on echocardiography was LVDD 29/50 (58%), next to which was PH 24/50 (48%), followed by LVH 4/50 (8%) and LVSD 3/50 (6%). The study showed 7/50 (14%) of normal cases.

Of 24 patients of PH, there were 16 (66.66%), 02 (8.33%), and 06 (25.0%) patients of mild, moderate, and severe respectively. Mean ± SD calculated for PH (n = 50) was 35.59 ± 15.47.

Of 29 patients with LVDD, 20(68.96%) were of Grade 1, 8 (27.58%) of Grade 2, and 01 (3.44%) of Grade 3.

The severity of PH, COR-P, and LVSD were increasing with increasing severity of COPD as shown in Table 1 and Figure 1. To conclude, except LVDD and LVH all other cardiac changes increased with increase of COPD severity. In details, if we note that Grade 1 LVDD is more common in moderate COPD cases but Grade 2 and Grade 3 LVDD in severe COPD cases shown in Figure 2.

Figure 3 explains the relation of FEV1 to COR-P suggesting that moderate COPD, severe, and very severe COPD has a direct linear relation to COR-P.

Figure 4 explains the linear relation between FEV1 and mean PH.

Figure 5 explains the correlation between FeV1 and PH in a form of scatter diagram. Pearson's correlation coefficient (r) value calculated is −0.45, i.e., with an increase in FEV1 there is fall in mean PH.

DISCUSSION

There are various cardiac changes seen in the patients suffering from COPD. Right-sided cardiac dysfunction and PH are one of the main established complications described in many studies done worldwide. Our study has added a little more strength to the various studies by proving the changes of PH and COR-P in COPD and by direct correlation between their severities. The Pearson correlation coefficient value of −0.45 is suggestive of mild negative correlation. This negative value describes that with every decrease in FEV1 there is an increase in PH values. Cigarette smoking and

Table 1: Comparison between severity of chronic obstructive pulmonary disease and cardiac changes

Cardiac changes	Moderate COPD (n=29)	Severe COPD (n=21)	Total (n=50)
Normal	05	02	07
PH	08	16	24
COR-P	06	10	16
LVDD	17	12	29
LVSD	01	02	03
LVH	03	01	04

PH: Pulmonary hypertension, COR-P: Cor-pulmonale, LVDD: Left ventricular diastolic dysfunction, LVSD: Left ventricular systolic dysfunction, LVH: Left ventricular hypertrophy

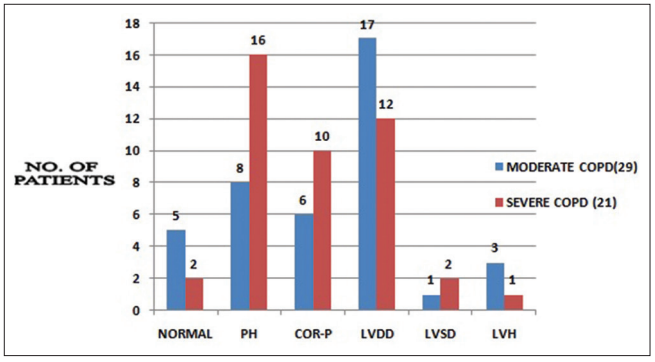

Figure 1: Correlation graph of chronic obstructive pulmonary disease and cardiac changes

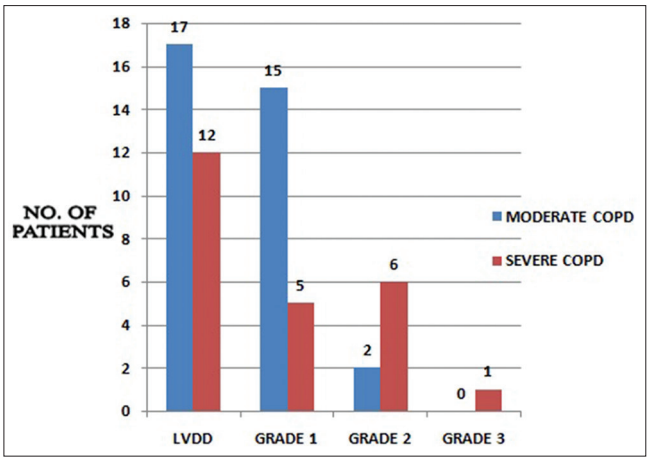

Figure 2: Correlation graph of chronic obstructive pulmonary disease and left ventricular diastolic dysfunction

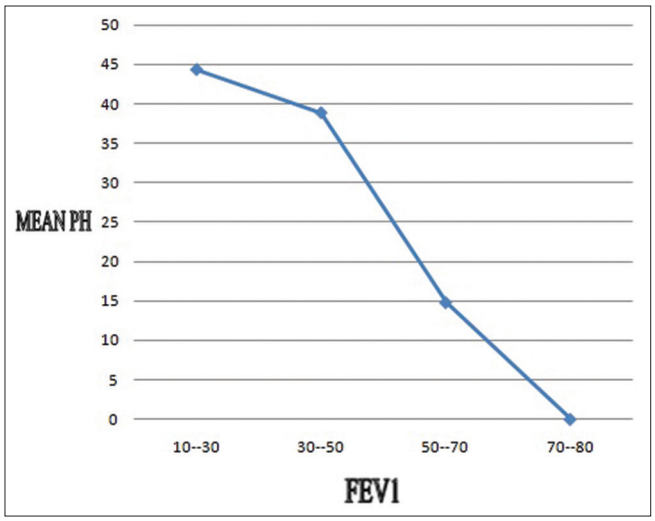

Figure 4: Correlation of forced expiratory volume in 1 s with means pulmonary hypertension

other exposure factors lead to inflammatory changes which disrupt the vascular pulmonary endothelium and on the other hand changes of chronic bronchitis and emphysema leads to chronic hypoxic conditions which result into pulmonary artery remodeling and vasoconstriction. The other mechanism leading to the damage is the change in intrinsic pulmonary vasodilator substances such as prostacyclin synthase, decrease in endothelial nitric oxide synthase and increase in endothelial 1. As a result, we see remodeling, changes in respiratory mechanics and also, increase in blood viscosity. All these factors lead to PH. PH increases the afterload of right ventricle and increase of right ventricular work as well. If we summarize the whole mechanism of COPD, hypoxic vasoconstriction, and PH will result into right ventricular hypertrophy and even its dilatation giving a clinical presentation of the right heart failure.

There are no exact data of PH prevalence in COPD; pulmonary artery pressures were seen elevated in about 20–90% of patients when measured by right heart

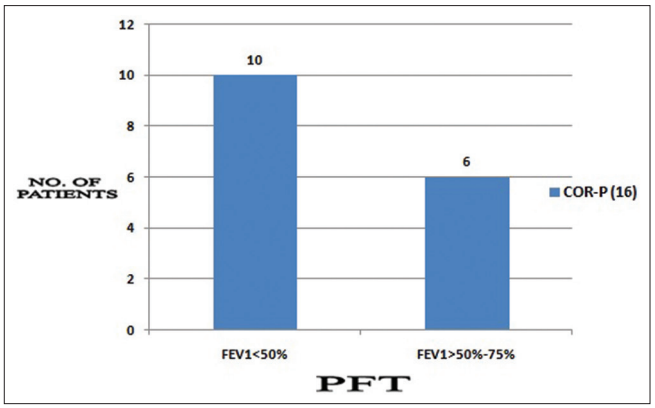

Figure 3: Frequency of cor-pulmonale in relation to forced expiratory volume in 1 s

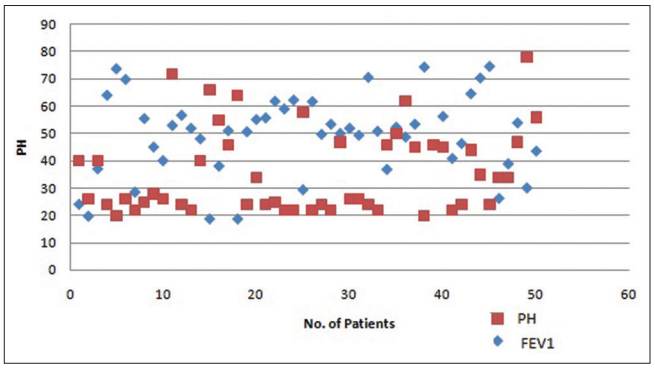

Figure 5: Correlation between pulmonary hypertension and forced expiratory volume in 1 s (scatter chart)

catheterization, with evidence of changing severity in pulmonary hemodynamics with the severity in airflow obstruction.[23] Two studies have shown an abnormal increase in MPAP (Ppa) in COPD of 0.4–0.6 mmHg per year. These studies illustrate that PH in COPD progresses slowly and occur in mild as well as severe forms of disease.[24,25]

Several studies have demonstrated the prognostic value of PH in COPD patients. Severe the PH more poor the prognosis, even in patients of COPD receiving long-term oxygen therapy. In one of the studies showing the 5 years survival rate were 50% in patients with mild PH (20–30 mmHg), 30% in those with moderate and severe PH (30–50 mmHg), and 0% in small group of patients suffering from severe PH (>50 mmHg). This study finding reveals 48% patients of the various severity of COPD has findings for PH that is almost similar to the previous studies. The frequencies of PH in moderate and severe COPD were 33.33% and 66.66%, respectively which is comparable to other study in which findings were 43% and 68%, respectively.[26]

In our study, there is direct linear correlation seen between PH and severity of COPD (FEV1). Previous studies showed the frequency of severe PH in COPD about 1–3%[27,28] but in our study, it has shown a high rise of 12% which could be explained as the study included only moderate and severe COPD cases.

COR-P was present in 32% of patients in our study. Approximately, about 25% patients of COPD develop COR-P.[29] One of the autopsy study showed 40% patients of COPD had COR-P.[23] In comparison, the results are matching to our study.

The cause of LVDD in COPD patients could be due to chronic hypoxemia leading to the changes in myocardial relaxation, distension, and lung hyperinflation making the parietal pleura stiff and similarly the walls of cardiac fossa adding the load to the walls of ventricle and also due to ventricular interdependence. In our study, LVDD was present in 58% of patients as compared to 47.5% seen in the study done by Gupta *et al*.[23]

One of the limitations of our study was a small size, the other factors being not able to perform the right sided heart catheterization or employ transoesophageal echocardiography. Further well designed cohort studies and use of future three dimensional echocardiography with optimal sample size will be helpful in defining the role of echocardiography in COPD patients.

CONCLUSION

The study shows high prevalence of cardiac co-morbidities such as PH, COR-P, LV dysfunction in COPD patients. The severity of complications increases with severity of COPD and makes a linear relation. This relation was also seen in Grade 2 and Grade 3 LV dysfunction and was not seen in Grade 1.

Hence, our study put emphasis on cardiac screening of all COPD patients.

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Conflicts of interest

There are no conflicts of interest.

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