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Evaluation of Cardiac Changes and Pulmonary Hypertension in COPD Patients: ECG and 2D ECHO Study

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ABSTRACT
COPD often leads to cardiac complications, including right ventricular dysfunction and pulmonary hypertension (PH). This study evaluates these changes using ECG and 2D ECHO. Aim of the study was to assess cardiac abnormalities in COPD patients and investigate the correlation between ECG findings and echocardiographic parameters. A cross-sectional study of 110 COPD patients was conducted at Mamata Academy of Medical Sciences, Hyderabad. Key parameters such as right ventricular size, tricuspid regurgitation velocity (TRV), pulmonary artery systolic pressure (PASP), left ventricular ejection fraction (LVEF), diastolic dysfunction and pericardial effusion were analyzed using ECG and 2D ECHO. In this study of 110 COPD patients, right ventricular dysfunction and pulmonary hypertension were common findings, with a strong correlation (r=0.96) between tricuspid regurgitation velocity (TRV) and pulmonary artery systolic pressure (PASP). Pulmonary hypertension (PASP>30 mmHg) was prevalent and left ventricular diastolic dysfunction was present in 50.5% of patients. Pericardial effusion was observed in 30.7% of cases. While ECG detected right heart strain, 2D ECHO provided a more comprehensive assessment of cardiac dysfunction. Cardiac complications, particularly right ventricular dysfunction and pulmonary hypertension, are common in COPD. 2D ECHO is valuable in assessing these conditions, with regular cardiovascular monitoring recommended for COPD patients.

INTRODUCTION

Chronic Obstructive Pulmonary Disease (COPD) is a major cause of morbidity and mortality worldwide, characterized by persistent respiratory symptoms and airflow limitation. COPD not only affects the lungs but also has significant extrapulmonary manifestations, particularly impacting the cardiovascular system[1]. Pulmonary hypertension (PH) is a frequent and serious complication in patients with advanced COPD, resulting from chronic hypoxia and vascular remodeling[2]. This elevation in pulmonary arterial pressure places increased strain on the right ventricle, leading to right heart dysfunction, which can progress to right heart failure, or cor pulmonale, over time. Evaluating cardiac changes in COPD, particularly in relation to PH, is crucial for early detection, prognosis, and management[3].

Two commonly used non-invasive modalities for assessing these cardiac changes are electrocardiography (ECG) and two-dimensional echocardiography (2D ECHO). ECG can reveal signs of right heart strain, right ventricular hypertrophy, and arrhythmias, while 2D ECHO provides detailed insights into the structure and function of the heart, including pulmonary artery pressure estimation, right ventricular size, and contractility[4]. Despite the availability of these diagnostic tools, there is a lack of consensus on how best to use ECG and 2D ECHO together in clinical practice for comprehensive cardiac evaluation in COPD patients with suspected PH. Moreover, the correlation between ECG findings and echocardiographic evidence of PH remains under-explored, representing a significant research gap.

Previous studies have highlighted the importance of cardiac evaluation in COPD patients, but few have focused specifically on the combined use of ECG and 2D ECHO for detecting and quantifying the impact of pulmonary hypertension[5]. Most studies have either focused on one modality alone or have limited their scope to right heart dysfunction without exploring the wider implications of PH[6]. Furthermore, data on the prognostic value of cardiac changes identified through these methods in COPD patients are limited. There is a clear need for research that bridges this gap by providing a comprehensive evaluation of how ECG and 2D ECHO can be used synergistically to detect and manage PH in COPD patients and how these findings correlate with disease severity and outcomes.

Several studies have explored cardiac dysfunction in COPD patients. Ozer *et al.* (2011) investigated right ventricular dysfunction in COPD patients using 2D ECHO and found significant correlations with disease severity[7]. Similarly, Lazovic *et al.* (2013) examined the role of ECG in detecting right ventricular hypertrophy in COPD patients, showing that ECG markers alone might miss early cardiac involvement[8]. However, neither of these studies thoroughly explored the combined use of ECG and 2D ECHO in assessing pulmonary hypertension, nor did they fully evaluate how cardiac changes impact the clinical outcomes of these patients.

This study aims to evaluate cardiac changes and the presence of pulmonary hypertension in COPD patients using both ECG and 2D ECHO. The primary objective is to determine the prevalence of cardiac abnormalities, particularly right ventricular dysfunction and PH and to assess the correlation between ECG findings and echocardiographic evidence. The study also seeks to establish the prognostic significance of these cardiac changes, helping clinicians better manage COPD patients at risk of cardiovascular complications.

MATERIALS AND METHODS

This is a prospective cross-sectional observational study conducted at the Department of Respiratory Medicine, Mamata Academy of Medical Sciences, Hyderabad. The study included 110 COPD patients diagnosed according to the GOLD (Global Initiative for Chronic Obstructive Lung Disease) criteria, who were attending the Respiratory Medicine outpatient department and inpatients admitted for COPD exacerbations.

Inclusion Criteria:

- Patients aged 40 years and above with a confirmed diagnosis of COPD based on spirometry (post-bronchodilator FEV1/FVC ratio<0.7).
- Patients willing to give informed consent.
- Patients in stable condition without any acute exacerbations at the time of cardiac evaluation.

Exclusion Criteria:

- Patients with known primary heart disease (e.g., ischemic heart disease, congenital heart disease).
- Patients with other pulmonary diseases like interstitial lung disease, pulmonary embolism, or tuberculosis.
- Patients with severe renal or hepatic dysfunction.
- Patients with significant valvular heart disease or any other cardiac condition precluding accurate assessment of right heart function.

A total of 110 patients were included in the study, calculated based on a confidence level of 95% and an expected prevalence of cardiac changes in COPD patients. The sample size was determined using standard sample size calculation formulae for cross-sectional studies.

Data Collection: Data were collected using a pre-structured proforma, which included demographic details (age, gender, smoking history), clinical history (duration of COPD, comorbidities) and detailed physical examination findings. Baseline pulmonary function tests (spirometry) were performed to assess disease severity.

Investigations:

- **Electrocardiography (ECG):**
- A 12-lead ECG was performed for each patient to identify signs of right heart strain, right ventricular hypertrophy (RVH), right bundle branch block (RBBB) and other arrhythmias.
- Specific ECG criteria for RVH and evidence of pulmonary hypertension (P pulmonale) were noted.
- **Two-Dimensional Echocardiography (2D ECHO):**
- A detailed 2D ECHO was conducted to evaluate right ventricular size, function and pulmonary artery pressure.
- Tricuspid regurgitation velocity (TRV) was used to estimate pulmonary artery systolic pressure (PASP). Pulmonary hypertension was defined as PASP >30 mmHg.
- Parameters like right ventricular end-diastolic diameter, right atrial size, left ventricular function (ejection fraction) and tricuspid annular plane systolic excursion (TAPSE) were recorded.
- Left ventricular diastolic dysfunction and other echocardiographic findings such as pericardial effusion, if any, were also noted.

Statistical Analysis: The collected data were entered into Microsoft Excel and analyzed using SPSS software version 25.0. Descriptive statistics were used to summarize patient characteristics. Continuous variables were expressed as mean± standard deviation (SD) and categorical variables as frequencies or percentages. Statistical significance was set at p-value <0.05.

RESULTS AND DISCUSSIONS

Table 1: Demographic Characteristics of the Study Population

Parameter	Mean	Standard Deviation
Age	64.59	5.92
Smoking History (Pack Years)	20.29	11.6
Male (%)	65.0	
Female (%)	35.0	

The table 1 presents key demographic data from the 110 COPD patients. The mean age was 64.59 years (SD 5.92) and the average smoking history was 20.29 pack years (SD 11.6), indicating varied smoking exposure. Males made up 65% of the cohort, while females accounted for 35%, reflecting the typical gender distribution seen in COPD populations. These details provide essential context for understanding the study results.

The figure 1outlines the clinical characteristics of the 110 COPD patients. The mean duration of COPD was 8.53 years (SD 3.45), indicating long-term disease in most patients. The average number of comorbidities was 1.65 (SD 0.91), suggesting that many patients had additional health conditions, which is common in COPD. The mean oxygen saturation was 90.1% (SD 2.66), reflecting the compromised respiratory function

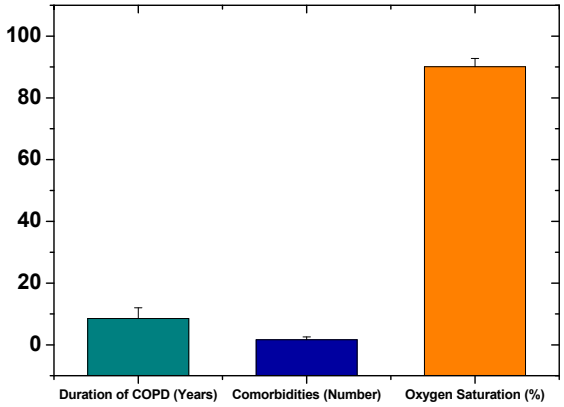

Fig. 1: Clinical Characteristics of the Study Population

typically observed in COPD patients. These clinical parameters help to provide a clear profile of the disease burden and associated health issues in the study group.

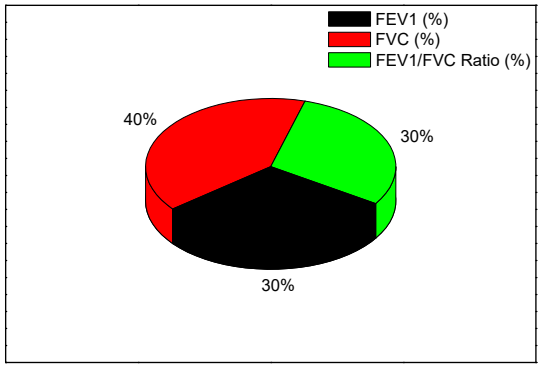

Fig. 2: Baseline Pulmonary Function Test Results

The figure 2 presents the baseline pulmonary function test results of the 110 COPD patients. The mean FEV1 (Forced Expiratory Volume in 1 second) was 49.65% (SD 11.72), indicating moderate to severe airflow limitation in the majority of patients. The mean FVC (Forced Vital Capacity) was 66.06% (SD 6.43), and the mean FEV1/FVC ratio was 49.0% (SD 6.71), confirming obstructive lung disease consistent with the diagnosis of COPD. These pulmonary function parameters are crucial in assessing the severity of airflow obstruction and disease progression in the study population.

Table 2: Echocardiographic Parameters of Right Heart Function

Parameter	Mean	Standard Deviation
Right Ventricular Size (mm)	31.64	2.17
Right Ventricular Function (TAPSE mm)	20.70	1.55
Pulmonary Artery Pressure (mmHg)	38.86	2.45

The table 2 summarizes echocardiographic findings related to right heart function in the 110 COPD patients. The mean right ventricular size was 31.64 mm (SD 2.17), reflecting mild enlargement. Right ventricular function, assessed by tricuspid annular plane systolic excursion (TAPSE), had a mean of 20.70 mm (SD 1.55), indicating preserved but potentially borderline right heart function in some patients. The mean pulmonary artery pressure was 38.86 mmHg (SD

2.45), suggesting the presence of pulmonary hypertension in many patients.

Table 3: Tricuspid Regurgitation Velocity and Pulmonary Artery Systolic Pressure

Parameter	Mean	Standard Deviation
Tricuspid Regurgitation Velocity (TRV m/s)	2.90	0.21
Pulmonary Artery Systolic Pressure (PASP mmHg)	36.89	2.86

The table 3 presents key echocardiographic measures related to pulmonary hypertension in the 110 COPD patients. The mean tricuspid regurgitation velocity (TRV) was 2.90 m/s (SD 0.21), indicating elevated pulmonary pressures. The mean pulmonary artery systolic pressure (PASP) was 36.89 mmHg (SD 2.86), consistent with the diagnosis of pulmonary hypertension in a significant portion of the patients. These findings highlight the increased burden of pulmonary hypertension in COPD, which plays a critical role in right heart dysfunction.

Table 4: Echocardiographic Parameters of Cardiac Structure and Function

Parameter	Mean	Standard Deviation
Right Ventricular End-Diastolic Diameter (mm)	30.14	1.62
Right Atrial Size (mm)	42.09	1.57
Left Ventricular Ejection Fraction (%)	59.15	2.03
Tricuspid Annular Plane Systolic Excursion (TAPSE mm)	21.04	1.28

The table 4 provides a summary of key echocardiographic parameters for assessing cardiac structure and function in the 110 COPD patients. The mean right ventricular end-diastolic diameter was 30.14 mm (SD 1.62), indicating mild right ventricular enlargement. The mean right atrial size was 42.09 mm (SD 1.57), showing slight enlargement of the atria. Left ventricular ejection fraction (LVEF), a measure of systolic function, was within normal limits with a mean of 59.15% (SD 2.03). Tricuspid annular plane systolic excursion (TAPSE), an indicator of right ventricular function, had a mean of 21.04 mm (SD 1.28), reflecting preserved right heart function. These parameters provide a comprehensive assessment of both right and left heart function in COPD patients.

Table 5: Prevalence of Left Ventricular Diastolic Dysfunction and Pericardial Effusion

Parameter	Count	Percentage
Left Ventricular Diastolic Dysfunction (Present)	51	50.49
Left Ventricular Diastolic Dysfunction (Absent)	50	49.50
Pericardial Effusion (Present)	31	30.69
Pericardial Effusion (Absent)	70	69.30

The table 5 shows the prevalence of left ventricular diastolic dysfunction and pericardial effusion among the 110 COPD patients. Left ventricular diastolic dysfunction was present in 51 patients (50.49%) and absent in 50 patients (49.50%), indicating a significant prevalence of diastolic dysfunction in this population. Pericardial effusion was observed in 31 patients (30.69%), while 70 patients (69.30%) had no effusion. These findings highlight the frequent occurrence of cardiac complications, particularly diastolic dysfunction, in COPD patients.

In this study, we aimed to evaluate cardiac changes in COPD patients with a specific focus on right ventricular size, function and pulmonary artery pressure, as well as the presence of pulmonary hypertension, left ventricular diastolic dysfunction and pericardial effusion using 2D ECHO. We also correlated electrocardiographic (ECG) findings with echocardiographic parameters. Our results provide important insights into the prevalence and severity of cardiac dysfunction in COPD patients, contributing to the growing body of evidence highlighting the cardiovascular complications associated with COPD.

Our study found a strong positive correlation (r=0.96) between tricuspid regurgitation velocity (TRV) and pulmonary artery systolic pressure (PASP), indicating that TRV can be a reliable non-invasive marker for estimating PASP in COPD patients. Pulmonary hypertension (defined as PASP>30 mmHg) was observed in a significant number of patients, in line with previous studies such as Hirachan *et al.* (2017), which showed similar echocardiographic evidence of right ventricular hypertrophy and elevated PASP in COPD patients[9]. Right ventricular end-diastolic diameter in our study had a mean value of 30.1 mm, suggesting mild to moderate right ventricular enlargement, a finding consistent with the literature where right ventricular dysfunction is commonly reported in moderate to severe COPD.

Our study also reported left ventricular diastolic dysfunction in 50.5% of patients. This is slightly higher than the prevalence reported by Abusaid *et al.* (2009), who identified diastolic dysfunction in approximately 40% of COPD patients[10]. The presence of diastolic dysfunction may be attributed to chronic hypoxia, systemic inflammation and increased after load due to elevated pulmonary pressures. Interestingly, left ventricular systolic function, as assessed by ejection fraction (LVEF), remained preserved in most patients, which is consistent with earlier studies indicating that COPD primarily affects the right side of the heart without significantly impairing left ventricular systolic function[11].

Pericardial effusion was present in 30.7% of patients, which aligns with findings from studies such as Moniz *et al.* (2018), where a prevalence of 25-35% was observed[12]. Pericardial effusion in COPD is often associated with severe pulmonary hypertension and chronic hypoxemia, highlighting the multisystem involvement in advanced COPD cases.

Our study findings are in agreement with several previous studies that have shown significant cardiac

involvement in COPD patients, particularly concerning right ventricular dysfunction and pulmonary hypertension. Earlier Studies also emphasized the role of echocardiography in identifying right heart changes in COPD[13]. However, our study adds to the literature by providing a more comprehensive assessment of cardiac parameters using both ECG and 2D ECHO, allowing for a better understanding of how these findings correlate with disease severity.

One notable observation in our study was the higher prevalence of left ventricular diastolic dysfunction, which suggests that, beyond pulmonary hypertension, COPD may exert a significant influence on left heart function, possibly due to shared risk factors like hypertension and systemic inflammation. This calls for further studies exploring the mechanisms underlying left heart involvement in COPD patients.

CONCLUSION

This study highlights the significant cardiac changes in COPD patients, particularly right ventricular dysfunction and pulmonary hypertension, as assessed by 2D echocardiography and ECG. The strong correlation between TRV and PASP underscores the utility of these non-invasive measures in early detection and management of cardiac complications in COPD. Additionally, the relatively high prevalence of left ventricular diastolic dysfunction and pericardial effusion suggests that COPD affects both sides of the heart, necessitating a holistic approach in the management of these patients. Our findings emphasize the need for regular cardiovascular screening in COPD patients, especially those with advanced disease, to improve outcomes and quality of life. Future research should focus on the long-term impact of these cardiac changes and potential interventions to mitigate cardiovascular complications in COPD.

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