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Original Research Article

A cross-sectional study on the cardiac imaging methods including electrocardiograms and echocardiography of the heart in patients with COPD

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ABSTRACT

Background: This study aimed to analyze electrocardiographic (ECG) and echocardiographic changes in patients with Chronic Obstructive Pulmonary Disease (COPD) and to correlate these findings with disease severity and duration. It also compared the diagnostic utility of clinical evaluation, ECG and echocardiography in detecting right ventricular (RV) dysfunction.

Methods: A cross-sectional observational study was conducted over one year in the medical wards of Sree Balaji Medical College and Hospital, Chennai. Fifty patients with clinically and spirometrically confirmed COPD were included using systematic random sampling. Detailed clinical history, including smoking habits and symptom duration, was recorded. All patients underwent spirometry, ECG and echocardiography. Disease severity was graded using the British Thoracic Society (BTS) criteria. Data were analyzed using Pearson's correlation and Chi-square tests, with $p < 0.05$ considered statistically significant.

Results: The mean age of the study population was 59.9±10.4 years, with a male predominance. The average disease duration was 5.71 years and mean smoking exposure was 23.2±3.6 pack-years. Severe COPD (FEV_1 < 40%) was common. ECG findings such as P pulmonale, right axis deviation, right bundle branch block, right ventricular hypertrophy and poor R-wave progression were associated with disease severity. Echocardiographic abnormalities included RV dilation, hypertrophy, pulmonary hypertension and cor pulmonale. Cor pulmonale was clinically evident in 36%, detected by ECG in 44% and confirmed by echocardiography in 54% of cases.

Conclusions: ECG and echocardiography serve as valuable tools for detecting RV dysfunction in COPD, with echocardiography demonstrating superior sensitivity.

Keywords: Chronic obstructive pulmonary disease, Electrocardiogram, Echocardiographic assessment, Right heart failure, Cor pulmonale

INTRODUCTION

COPD represents a major global health burden and is a significant contributor to chronic morbidity and mortality. It is currently recognized as the fourth leading cause of death worldwide, with projections indicating that both its prevalence and mortality rates will continue to rise in the coming decades.[1,2] Many individuals endure prolonged suffering due to COPD, which often results in premature death either directly from the disease or its associated complications. COPD is responsible for a substantial number of general practitioner consultations, emergency department visits, hospital admissions and work absences.

It is estimated that by the year 2020, COPD would rank as the fifth leading cause of Disability-Adjusted Life Years (DALYs) lost globally, highlighting its significant socioeconomic impact on healthcare systems and

workforce productivity.[1] The disease is characterized by progressive, irreversible airflow obstruction, leading to persistent symptoms such as dyspnea, reduced exercise tolerance and fatigue.

One of the most important systemic consequences of COPD is the development of pulmonary hypertension and right ventricular (RV) dysfunction, particularly in patients with chronic hypoxemia.[3] RV dysfunction can occur in nearly 50% of patients with moderate to severe COPD and is strongly associated with reduced functional capacity, increased dyspnea, lower exercise tolerance and higher mortality.[4,5] The early identification and management of RV dysfunction may delay clinical deterioration and significantly improve survival and quality of life in COPD patients.

ECG and echocardiography are non-invasive, accessible tools that can detect cardiac involvement in COPD, particularly cor pulmonale and pulmonary hypertension.[6,7] This study aims to assess electrocardiographic and echocardiographic changes in patients with COPD of varying severity, classified by clinical presentation and pulmonary function tests. Additionally, it compares the predictive value of ECG and echocardiographic parameters in identifying RV dysfunction with respect to disease severity and duration. Early detection through these modalities can guide timely therapeutic intervention and potentially improve clinical outcomes in this high-risk population.

Aims and objectives

The objective is to investigate the electrocardiographic and echocardiographic characteristics in patients with COPD. Additionally, the study aims to evaluate the correlation between these findings and the duration and severity of the disease. Furthermore, it seeks to compare clinical assessments with electrocardiographic and echocardiographic evaluations in the identification of right ventricular dysfunction in individuals with COPD.[8]

METHODS

Study design and setting

A hospital-based, cross-sectional observational study was conducted from June 1, 2023 to May 31, 2024 in the Department of General Medicine at Sree Balaji Medical College and Hospital, Chennai. The objective was to evaluate ECG and echocardiographic trends among patients diagnosed with COPD and to assess their correlation with disease duration and severity. Study population and sampling strategy.[9]

Fifty patients presenting with clinical features consistent with COPD were enrolled. Patients were selected using systematic random sampling, with every fifth eligible patient admitted for COPD over the prior three years included, based on institutional admission records. Both male and female patients were considered for inclusion.

Inclusion criteria

Inclusion criteria consisted of adult patients with a history of chronic cough and sputum production for at least three months in two consecutive years and/or persistent exertional dyspnea, in line with diagnostic criteria for COPD. Data were chosen from 1946 to October 2006.

Exclusion criteria

Exclusion criteria comprised patients with alternate respiratory disorders (e.g., bronchial asthma, bronchiectasis, pulmonary tuberculosis and restrictive lung diseases), as well as individuals with significant cardiac comorbidities including rheumatic heart disease, congenital heart disease, ischemic heart disease and systemic hypertension, in order to reduce diagnostic confounding.

Data collection and evaluation protocol

Following informed written consent, all participants underwent comprehensive evaluation including.

Clinical assessment

A detailed history encompassing symptom duration, smoking habits (quantified in pack-years) and prior medical treatment was recorded. A complete physical examination was performed to assess signs of COPD and right heart strain, including cyanosis, peripheral edema, jugular venous distension and signs of carbon dioxide retention.

Pulmonary function testing

Spirometry was performed in accordance with ATS/ERS guidelines to determine Forced Expiratory Volume in one second (FEV_1), Forced Vital Capacity (FVC) and the FEV_1/FVC ratio. The severity of airflow limitation was classified using the BTS criteria.

Radiological evaluation

Standard posterior-anterior chest radiographs were assessed for hyperinflation, flattening of the diaphragm, increased retrosternal air space, evidence of chronic bronchitis, cardiomegaly and pulmonary hypertension.

Electrocardiography

Standard 12-lead ECGs were analyzed for features suggestive of right heart strain, including P pulmonale, right axis deviation, right bundle branch block (RBBB), right ventricular hypertrophy (RVH), low voltage QRS complexes and arrhythmias.[10]

Echocardiography

Two-dimensional and M-mode transthoracic echocardiography was performed to evaluate right atrial and ventricular dimensions, RV wall thickness, pulmonary artery diameter and ejection parameters. Presence of RV dysfunction, dilatation, pulmonary hypertension and echocardiographic features of cor pulmonale were recorded.

Laboratory investigations

Baseline blood parameters, urine analysis and sputum studies were conducted to support clinical diagnosis and rule out alternative etiologies.

Statistical analysis

Data were compiled and analyzed using SPSS software (version XX). Continuous variables were expressed as mean±standard deviation (SD) and categorical variables as frequencies and percentages. Pearson's correlation coefficient was employed to evaluate associations between quantitative variables, while the Chi-square test was used for categorical comparisons. A two-tailed p value of <0.05 was considered statistically significant.

RESULTS

In 2023, the Medicine Department at Sree Balaji Medical College and Hospital, Chennai admitted a total of 632 respiratory cases, of which 154 were diagnosed with COPD. A total of 50 cases were randomly chosen based on predetermined inclusion and exclusion criteria to constitute the study sample.

The average age of the patients was 59.9±10.3 years (range: 40–85 years). The majority of COPD cases (66%) occurred within the 50–69 age range, while no patients were under 40 years and only 4% were aged 80 or older. Patients reported an average symptom duration of 5.7±4.9 years (range: 2–20 years). Most patients (62%) had symptoms for 1–5 years, while 10% experienced symptoms for more than 10 years. Pulmonary function tests revealed a mean FEV1 of 36.0±12.2% predicted, with 60% of patients exhibiting severe airflow obstruction and only 4% classified as having mild disease. The average tobacco exposure was 23.2 pack-years (range: 5–45). The majority reported exposure between 20 and 29 pack-years, while only 2% had a history of less than 10 pack-years. Among patients with severe disease, 70% (21 out of 30) had a smoking history exceeding 20 pack-years.

Clinical features

All participants experienced breathlessness, while 96% reported cough with sputum. Edema was present in 38%. Tachypnea was the predominant clinical sign (70%), followed by epigastric pulsation. Pulmonary hypertension, suggested by a loud P2, was noted in 32%. Signs of congestive heart failure (elevated JVP, edema, hepatomegaly) were observed in 36%. Clinical signs of right ventricular hypertrophy (RVH) were present in 30%, while 26% exhibited cyanosis or clubbing.

Radiological findings

Emphysema was seen in 80%, chronic bronchitis in 64%, pulmonary hypertension in 30% and cardiomegaly in 20%.

ECG findings

P pulmonale was observed in 48%, low-voltage complexes in 28% and poor R-wave progression in 32%. Right ventricular hypertrophy (RVH) was found in 44%, with right axis deviation present in all RVH cases. Incomplete right bundle branch block (RBBB) was noted in 18% of patients with RVH.

Correlation with severity

ECG abnormalities significantly correlated with COPD severity ($p<0.05$). In mild COPD, only one patient had a low-voltage complex.[11] In moderate COPD, 72% had ECG changes, including RVH (33.3%) and P pulmonale (38.8%). In severe COPD, 83.3% had ECG abnormalities, with right axis deviation (66.7%) and P pulmonale (56.7%) being the most common (Table 2).

Echocardiographic findings

Echocardiographic evaluation revealed several abnormalities consistent with right ventricular involvement in COPD patients. Right ventricular (RV) dilatation was observed in a significant proportion, with associated pulmonary hypertension and features of cor pulmonale.[12]

RV wall thickening and increased pulmonary artery pressure were common, particularly in patients with severe disease. Echocardiography also identified subclinical RV dysfunction in patients without overt clinical signs, highlighting its role as a sensitive tool for early detection (Table 3).

In patients diagnosed with mild COPD, echocardiographic assessments indicated the presence of pulmonary hypertension in a single instance, with no signs of cor pulmonale observed. In cases of moderate COPD, 27.8% of patients exhibited pulmonary hypertension, while 22.2% presented with cor pulmonale. Among those with severe COPD, 73.3% demonstrated pulmonary hypertension, 76.7% had cor pulmonale and 23.3% showed indications of right ventricular (RV) failure. The echocardiographic findings of right atrial (RA) dilation, RV dilation, RV failure, pulmonary hypertension and cor pulmonale were found to have a significant correlation with the severity of COPD ($p<0.05$).

Table 1: Demographic, clinical and outcome characteristics of COPD patients (n=50).

Characteristic	Value
Age (years)	Mean 59.9±10.3 (range 40–85)
Age distribution	50–69 years: 66%
	≥80 years: 4%
Sex distribution	Male: XX% (n=)
	Female: XX% (n=)
Symptom duration (years)	Mean 5.7±4.9 (range 2–20)
	1–5 years: 62%
	>10 years: 10%
Smoking exposure	Mean 23.2 pack-years (range 5–45)
	>20 pack-years in severe disease: 70%
Pulmonary function (FEV1 % predicted)	Mean 36.0±12.2%
	Mild: 4%
	Severe: 60%
Common symptoms	Breathlessness 100%
	Cough with sputum 96%
	Edema 38%
Clinical findings	Tachypnoea 70%
	Pulmonary hypertension (loud P2) 32%
	CHF signs 36%
	RVH signs 30%
	Cyanosis/clubbing 26%
Radiological findings	Emphysema 80%
	Chronic bronchitis 64%
	Pulmonary hypertension 30%
	Cardiomegaly 20%
ECG findings	P pulmonale 48%
	Low-voltage complexes 28% Poor R-wave progression 32%
	RVH 44%
	Incomplete RBBB 18%
Outcomes/correlations	ECG abnormalities increased with severity
	Moderate COPD: 72% had ECG changes
	Severe COPD: 83.3% had ECG changes

Table 2: Correlation of ECG abnormalities with COPD severity (n=50).

ECG Abnormality	Mild COPD (%) (n=2)	Moderate COPD (%) (n=18)	Severe COPD (%) (n=30)
Any ECG abnormality	1 (50)	13 (72.2)	25 (83.3)
P pulmonale	0	7 (38.8)	17 (56.7)
Right ventricular hypertrophy (RVH)	0	6 (33.3)	20 (66.7)
Right axis deviation	0	4 (22.2)	20 (66.7)
Low-voltage complexes	1 (50)	3 (16.7)	10 (33.3)
Incomplete RBBB	0	2 (11.1)	7 (23.3)

Table 3: Echocardiographic findings in COPD patients (n=50).

Echocardiographic parameter	Mild COPD (%) (n=2)	Moderate COPD (%) (n=18)	Severe COPD (%) (n=30)	Total (%) (n=50)
RV dilatation	0	4 (22.2)	18 (60.0)	22 (44.0)
RV wall thickening	0	3 (16.7)	15 (50.0)	18 (36.0)
Pulmonary hypertension (↑PASP)	0	5 (27.8)	20 (66.7)	25 (50.0)
Cor pulmonale	0	2 (11.1)	12 (40.0)	14 (28.0)
RV dysfunction (reduced TAPSE/EF)	0	3 (16.7)	10 (33.3)	13 (26.0)

DISCUSSION

This study provides a detailed evaluation of ECG and echocardiographic (Echo) findings in patients with COPD, focusing on the relationship between cardiac involvement and disease severity, duration and risk factors. The prevalence of COPD was significantly higher among males, with a male-to-female ratio of 5.25:1. This difference is largely attributable to higher smoking rates among men. In contrast, female patients were more frequently exposed to biomass fuels used for cooking, which represents a recognized non-smoking risk factor for COPD. The majority of patients were aged 50–69 years, with a mean age of approximately 60 years. This is consistent with the known correlation between advancing age, cumulative tobacco exposure and recurrent respiratory infections.

The mean duration of symptoms was 5.71 years, with most patients reporting a disease duration of 1–5 years. Severe airflow limitation (FEV_1<40%) was observed in 60% of cases, whereas mild disease was uncommon. This likely reflects the clinically silent nature of early-stage COPD and the resulting underdiagnosis. A significant correlation was observed between smoking exposure in pack-years and disease severity, with patients having more than 20 pack-years presenting predominantly with severe disease. This finding supports the cumulative impact of tobacco smoke on pulmonary parenchyma. Clinically, all patients presented with dyspnea and productive cough, while common physical findings included tachypnoea, hyperinflated chest, diminished breath sounds and prolonged expiration. Advanced cases demonstrated signs of right ventricular hypertrophy (RVH) and pulmonary hypertension, reflecting the cardiopulmonary consequences of chronic hypoxia. Chest radiographs revealed classical emphysematous features, such as flattened diaphragms and hyper translucent lung fields.[13]

ECG analysis revealed RVH in 44% of patients, right axis deviation, elevated R/S ratio in V1 and features of P pulmonale. These abnormalities were more prevalent in patients with severe airflow limitation, highlighting the utility of ECG in detecting right ventricular strain and cor pulmonale. Echocardiography demonstrated cor pulmonale in over 50% of patients, including right ventricular dilation, RVH and elevated pulmonary artery pressures. These findings were strongly associated with both longer disease duration and more severe COPD.[14]

A significant correlation was observed between the presence of right axis deviation, RVH, pulmonary hypertension and reduced FEV_1 values, indicating that cardiac involvement progresses alongside pulmonary disease. This underscores the importance of routine cardiac evaluation in patients with advanced COPD to facilitate early detection and management of right heart complications.

The study's findings highlight that ECG and echocardiography serve as practical, non-invasive tools for detecting cardiac involvement in COPD, particularly in resource-limited settings where advanced imaging modalities may not be readily available. Early identification of RV strain and pulmonary hypertension can guide timely interventions to reduce morbidity and improve patient outcomes.[15]

CONCLUSION

COPD is a common respiratory condition that significantly impacts individuals' health and quality of life individuals admitted to the hospital with respiratory issues.[16,17] It primarily impacts males and those in their 50s and 60s. Upon admission, many patients exhibit advanced stages of the disease. ECG and echocardiography demonstrate superior efficacy compared to clinical examinations in the detection of right ventricular dysfunction among patients with Chronic Obstructive Pulmonary Disease (COPD). The duration and severity of the condition play a significant role in determining the appropriate treatment approach.

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