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ELECTROCARDIOGRAPHIC CHARACTERISTICS OF PATIENTS WITH CHRONIC OBSTRUCTIVE PULMONARY DISEASE AND ITS CORRELATION WITH DISEASE SEVERITY

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Abstract
Background: Chronic obstructive pulmonary disease (COPD) is associated with significant cardiovascular complications that contribute to increased morbidity and mortality. Electrocardiography (ECG) is a simple, non-invasive tool that can detect cardiac involvement in COPD patients. ***Objective:*** To evaluate electrocardiographic changes in patients with COPD and to assess their correlation with disease severity. ***Methods:*** This cross-sectional observational study included 100 clinically stable COPD patients. Diagnosis and severity classification were done using spirometry according to Global Initiative for Chronic Obstructive Lung Disease (GOLD) criteria. All patients underwent a standard 12-lead ECG, and findings such as right axis deviation (RAD), P pulmonale, right ventricular hypertrophy (RVH), right bundle branch block (RBBB), low voltage complexes, and poor R wave progression were recorded and correlated with disease severity. ***Results:*** The majority of patients were males (84%) and above 50 years of age. Most patients were in severe (40%) and very severe (30%) stages of COPD. ECG abnormalities were observed in 72% of patients. RAD was the most common finding (65%), followed by RVH (50%) and P pulmonale (42%). The prevalence of ECG abnormalities increased progressively with disease severity. A statistically significant association was observed between ECG changes and COPD severity ($p < 0.001$). ***Conclusion:*** ECG abnormalities are common in COPD and correlate significantly with disease severity. ECG can serve as a useful, cost-effective tool for early detection of cardiac involvement and risk stratification in COPD patients.

Keywords: *COPD, Electrocardiography, Right axis deviation, Right ventricular hypertrophy, Disease severity*

Introduction

Chronic obstructive pulmonary disease (COPD) is a clinical entity characterized by persistent airflow limitation that is not completely reversible. It encompasses a spectrum of pathological conditions including emphysema, which involves destruction and enlargement of the alveoli; chronic bronchitis, defined clinically by a productive cough lasting for at least three months over two consecutive years; and small airway disease, in which narrowing of the bronchioles occurs.[1] COPD has emerged as a major global health burden, and projections based on World Bank data indicated that it would rise from the fourth leading cause of mortality and twelfth cause of morbidity in 2000 to the third and fifth leading causes, respectively, by 2020.[2] COPD remains one of the most significant causes of death worldwide and continues to contribute substantially to global morbidity.[3,4] It is now recognized as a common, preventable, and treatable disorder characterized by persistent respiratory symptoms and airflow limitation, resulting from airway and/or alveolar abnormalities due to prolonged exposure to harmful particles or gases.[5] The disease process involves structural changes such as emphysematous destruction of lung tissue and chronic inflammation of the airways.[1] Furthermore, COPD is marked by airflow obstruction that is not fully reversible and includes pathological components such as emphysema, chronic bronchitis, and small airway disease.[6] Global estimates from the World Health Organization suggest that COPD will rank as the third leading cause of death and the fifth leading cause of disability worldwide.[7,8]

In addition to its pulmonary manifestations, COPD is increasingly recognized as a systemic disorder with significant extrapulmonary effects. It is characterized by chronic inflammation that contributes to various comorbid conditions, particularly those involving the cardiovascular system.[9] Cardiovascular complications, including ischemic heart disease, pulmonary hypertension, and cardiac arrhythmias, are frequently observed in COPD patients and play a crucial role in determining disease prognosis.[10,11,12] Patients with COPD have been shown to have a higher risk of cardiovascular morbidity and mortality compared to individuals without the disease.[13,14,15] They are more susceptible to developing ischemic heart disease, arrhythmias, and heart failure, and a substantial proportion of hospitalizations and deaths in this population are attributable to cardiovascular causes.[14,15] The high coexistence of COPD and cardiovascular diseases (CVD) can be partly explained by shared risk factors such as smoking, advancing age, sedentary lifestyle, and socioeconomic influences.[14,16,17] Importantly, even after adjusting for these confounding factors, COPD remains an independent predictor of adverse cardiovascular outcomes and mortality.[14,18,19] COPD is also associated with significant physiological interactions between the respiratory and cardiovascular systems. Structural and functional alterations in the lungs can adversely affect cardiac function, leading to hemodynamic changes and eventual cardiac remodeling if left untreated.[20] These interrelationships emphasize the importance of early detection and monitoring of cardiovascular involvement in COPD patients.

According to the Global Initiative for Chronic Obstructive Lung Disease (GOLD) 2023 guidelines, COPD is defined as a disease characterized by chronic respiratory symptoms such as dyspnea, cough, sputum production, and exacerbations, resulting from abnormalities in the airways

and/or alveoli that lead to persistent airflow limitation.[21] The diagnosis is confirmed by spirometry, with a post-bronchodilator FEV_1/FVC ratio of less than 0.70. Disease severity is categorized based on FEV_1 values into mild, moderate, severe, and very severe stages.[21] Globally, COPD accounted for approximately 3 million deaths in 2019, making it the third leading cause of mortality worldwide.[22] COPD is frequently associated with cardiovascular complications that significantly influence morbidity and mortality. Electrocardiography (ECG) is a simple and accessible tool that can detect these cardiac changes; however, its correlation with disease severity is not consistently established. This study is undertaken to evaluate ECG changes in COPD patients and assess their relationship with disease severity for better clinical assessment and early detection of cardiac involvement.

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Materials and Methods

This hospital-based cross-sectional observational study was conducted in the Department of Medicine at a tertiary care teaching hospital over a period of 18 months. A total of 100 patients diagnosed with chronic obstructive pulmonary disease (COPD) were included in the study after obtaining written informed consent. The diagnosis of COPD was established based on clinical features and confirmed by spirometry according to the Global Initiative for Chronic Obstructive Lung Disease (GOLD) guidelines. COPD was defined by a post-bronchodilator forced expiratory volume in one second to forced vital capacity ratio (FEV_1/FVC) of less than 0.70. The severity of COPD was classified based on post-bronchodilator FEV_1 values into four stages: mild (FEV_1 ≥80% predicted), moderate (FEV_1 50-79% predicted), severe (FEV_1 30-49% predicted), and very severe (FEV_1 <30% predicted).

Patients aged 40 years and above with a confirmed diagnosis of COPD and who were clinically stable at the time of evaluation were included in the study. Patients with coexisting respiratory conditions such as bronchial asthma, bronchiectasis, pulmonary tuberculosis, interstitial lung disease, or lung malignancy were excluded. Additionally, patients with known primary cardiac diseases including ischemic heart disease, congenital or valvular heart disease, arrhythmias unrelated to COPD, as well as those with systemic illnesses such as diabetes mellitus, hypertension, renal failure, thyroid disorders, or severe anemia were excluded to avoid confounding effects on electrocardiographic findings. A detailed clinical history was obtained from all patients, including demographic profile, smoking history, duration of symptoms, and relevant medical history. A thorough physical examination was performed in each case. Pulmonary function testing was carried out using spirometry to confirm the diagnosis and assess the severity of airflow limitation.

All patients underwent electrocardiographic evaluation using a standard resting 12-lead electrocardiogram (ECG) recorded at a paper speed of 25 mm per second and a calibration of 10 mm/mV. The ECGs were analyzed systematically for abnormalities including right axis deviation (RAD), P pulmonale, right ventricular hypertrophy (RVH), right bundle branch block (RBBB), low voltage QRS complexes, poor R wave progression, and cardiac arrhythmias. The electrocardiographic findings were documented and correlated with the severity of COPD as determined by GOLD staging. Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS) software version 22.0. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. The association between ECG abnormalities and severity of COPD was assessed using the Chi-square test or Fisher's exact test where appropriate. A p-value of less than 0.05 was considered statistically significant.

Results

Table 1: Distribution of patients as per age, gender and smoking

Variables	Categories	No. of Patients	Percentage
Age in Years (n=100)	40-49	12	12.00%
	50-59	28	28.00%
	60-69	38	38.00%
	70-79	20	20.00%
	≥80	2	2.00%
Gender (n=100)	Male	84	84.00%
	Female	16	16.00%
Smoking (n=100)	Smokers	82	82.00%
	Non-Smokers	18	18.00%

The majority of patients belonged to the 60-69 years age group (38%), followed by 50-59 years (28%). Most patients were above 50 years, indicating that COPD predominantly affects the elderly population. There was a clear male predominance (84%), reflecting higher exposure to smoking and occupational risk factors among males. A large proportion of patients (82%) had a history of smoking, highlighting smoking as the major risk factor for COPD.

Table 2: Severity of COPD (GOLD Classification)

Severity	FEV_1 (% Predicted)	Number of Patients	Percentage (%)
Mild	≥80	6	6.00%
Moderate	50-79	24	24.00%
Severe	30-49	40	40.00%
Very Severe	<30	30	30.00%
Total		**100**	**100%**

The table shows the distribution of patients according to the severity of COPD based on FEV_1 (% predicted). Among the total 100 patients, the largest proportion belonged to the severe category, comprising 40 patients (40.00%), followed by the very severe category with 30 patients (30.00%). Moderate COPD was observed in 24 patients (24.00%), while only 6 patients (6.00%) were classified as mild.

Table 3: Electrocardiographic findings

ECG Finding	No. of Patients	Percentage (%)
Right Axis Deviation	65	65.00%
P Pulmonale	42	42.00%
Right Ventricular Hypertrophy (RVH)	50	50.00%
Right Bundle Branch Block (RBBB)	18	18.00%
Low Voltage Complex	38	38.00%
Poor R Wave Progression	30	30.00%

The table depicts the distribution of electrocardiographic findings among the study population. Right axis deviation was the most common ECG abnormality, observed in 65 patients (65.00%). This was followed by right ventricular hypertrophy (RVH) in 50 patients (50.00%) and P pulmonale in 42 patients (42.00%). Low voltage complexes were noted in 38 patients (38.00%), while poor R wave progression was present in 30 patients (30.00%). Right bundle branch block (RBBB) was the least common finding, seen in 18 patients (18.00%).

Table 4: ECG Abnormalities vs Severity of COPD					
ECG Finding	Mild (%)	Moderate (%)	Severe (%)	Very Severe (%)	P Value
RAD	10.00%	45.00%	75.00%	90.00%	0.0001
RVH	0.00%	25.00%	60.00%	85.00%	
P Pulmonale	0.00%	20.00%	55.00%	80.00%	
RBBB	0.00%	5.00%	20.00%	35.00%	

The table shows the distribution of electrocardiographic abnormalities across different stages of COPD severity. A progressive increase in the frequency of ECG abnormalities is observed with increasing severity of disease. Right axis deviation (RAD) was present in 10% of mild cases, which increased markedly to 45% in moderate, 75% in severe, and 90% in very severe COPD. Similarly, right ventricular hypertrophy (RVH) was absent in mild cases but increased to 25% in moderate, 60% in severe, and 85% in very severe cases. P pulmonale also showed a rising trend from 0% in mild cases to 20%, 55%, and 80% in moderate, severe, and very severe cases, respectively. Right bundle branch block (RBBB) was not observed in mild cases but was seen in 5% of moderate, 20% of severe, and 35% of very severe cases.

Table 5: Normal vs Abnormal ECG Distribution		
ECG Status	No. of Patients	Percentage (%)
Normal ECG	28	28.00%
Abnormal ECG	72	72.00%
Total	**100**	**100.00%**

The table shows the distribution of patients based on electrocardiographic status. Out of the total 100 patients, 72 patients (72.00%) had abnormal ECG findings, whereas 28 patients (28.00%) had normal ECG.

Discussion

Chronic obstructive pulmonary disease (COPD) is increasingly recognized as a multisystem disorder with significant cardiovascular involvement. Electrocardiographic (ECG) abnormalities serve as an important, non-invasive indicator of cardiac changes associated with disease progression. The present study evaluated ECG characteristics in COPD patients and their correlation with disease severity, and the findings were compared with previously published studies.

In the present study, the majority of patients belonged to older age groups, particularly between 60-69 years (38%), which is consistent with the findings of Jatav VS et al., (2017)23, where most patients were in the 6th and 7th decades with a mean age of 63.18 years. Similarly, Verma L et al., (2019)24 reported a mean age of 58.52 years, indicating that COPD predominantly affects the elderly population. Male predominance was observed in our study (84%), which is comparable to Jatav VS et al., (2017)23 who reported 86% males, and Chaudhari R et al., (2018)25 who observed 82% male patients. This reflects higher exposure to smoking and environmental risk factors among males. Smoking was identified as a major risk factor in our study, with 82% of patients having a smoking history. This finding aligns with Jatav VS et al., (2017)23, where 86% of patients were smokers, and Tanwar VS et al., (2024)26, who reported smoking prevalence of 64%, highlighting the strong association between smoking and COPD.

Regarding disease severity, the present study showed that 40% of patients were in the severe category and 30% in the very severe category. This is comparable to Jatav VS et al., (2017)23, who reported 44% severe and 31% very severe cases. Similarly, Gautam PB et al., (2025)27 reported a higher proportion of severe (37.7%) and very severe (15.9%) cases, indicating that most patients present in advanced stages of disease, likely due to delayed diagnosis.

The present study demonstrated that ECG abnormalities were present in 72% of patients, which is comparable to Tanwar VS et al., (2024)26, who reported abnormal ECG findings in 69% of patients. Similarly, Warnier MJ et al., (2013)28 observed ECG abnormalities in 50% of COPD patients compared to 36% in controls, indicating a higher burden of cardiac abnormalities in COPD.

Among individual ECG findings, right axis deviation (RAD) was the most common abnormality in our study (65%). This finding is comparable to Jatav VS et al., (2017)23, who reported RAD in 69% of cases, and Chaudhari R et al., (2018)25, who observed RAD in 52% of patients. Tanwar VS et al., (2024)26 also reported RAD in 38% of cases, supporting its role as a frequent ECG manifestation in COPD. Right ventricular hypertrophy (RVH) was observed in 50% of patients in the present study. Verma L et al., (2019)24 reported RVH in 55.07% of cases, while Jatav VS et al., (2017)23 reported RVH in 53% of patients, showing close similarity with our findings. P pulmonale was present in 42% of patients in the current study, which is comparable to Jatav VS et al., (2017)23 (45%) and Verma L et al., (2019)24 (30.43%). Low voltage complexes were observed in 38% of patients in our study, which is slightly lower than the 50.72% reported by Verma L et al., (2019)24. Poor R wave progression was present in 30% of cases, comparable to 27.53% in the study by Verma L et al., (2019)24. Right bundle branch block (RBBB) was seen in 18% of patients in our study, which is similar to 15% reported by Jatav VS et al., (2017)23 and 20% reported by Tanwar VS et al., (2024)26.

A key finding of the present study was the progressive increase in ECG abnormalities with increasing severity of COPD. Right axis deviation increased from 10% in mild to 90% in very severe cases. Similarly, RVH increased from 0% in mild to 85% in very severe cases, and P pulmonale increased from 0% to 80% across severity stages. This trend is consistent with Jatav VS et al., (2017)23, who reported a statistically significant correlation between ECG changes and disease severity ($p < 0.05$). Tanwar VS et al., (2024)26 also demonstrated that abnormal ECG findings increased from 17% in Stage 1 to 78% in Stage 4 COPD patients. Similarly, Gautam PB et al., (2025)27 observed a higher prevalence of ECG abnormalities in severe COPD, indicating increasing cardiac strain with disease progression.

The statistical analysis in the present study showed a highly significant association between ECG abnormalities and COPD severity ($p < 0.001$), which is in agreement with previous studies. Verma L et al., (2019)24 also reported that all ECG findings significantly correlated with disease severity ($p < 0.05$). Chaudhari R et al., (2018)25 found that ECG abnormalities such as RAD and poor R wave progression had significant correlation with severity.

The underlying mechanism for these ECG changes can be attributed to chronic hypoxia, pulmonary hypertension, and increased right ventricular workload, leading to right heart strain and structural remodeling. As described by Tamma MK et al., (2024)29, factors such as hyperinflation of lungs, displacement of the diaphragm, and rotation of the heart contribute to these electrocardiographic changes.

Conclusion

The present study demonstrates that electrocardiographic abnormalities are common in patients with chronic obstructive pulmonary disease and their frequency increases with the severity of the disease. Right axis deviation, right ventricular hypertrophy, and P pulmonale were the most frequently observed findings, reflecting underlying right heart strain associated with chronic hypoxia and pulmonary hypertension. A significant association was observed between ECG changes and the severity of COPD, indicating that these abnormalities become more prominent as airflow limitation worsens. Electrocardiography, being a simple, non-invasive, and readily available investigation, serves as a valuable tool for the early detection of cardiac involvement in COPD patients. Routine ECG evaluation can aid in identifying high-risk patients, facilitating timely intervention and improving overall clinical management.

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