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Original Article

ELECTROCARDIOGRAPHIC ALTERATIONS IN COPD: A MARKER OF DISEASE SEVERITY AND CARDIAC RISK

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ABSTRACT

Objective: Chronic Obstructive Pulmonary Disease (COPD) is associated with significant cardiovascular complications, often reflected in electrocardiographic (ECG) changes. Understanding these alterations can aid in assessing disease severity and predicting cardiac risk in COPD patients. This study aimed to evaluate ECG abnormalities in COPD patients and their correlation with disease severity.

Methods: A cross-sectional study was conducted on 138 COPD patients (62% male, 38% female). Standard 12-lead ECG recordings were analyzed for common abnormalities, including right axis deviation (RAD), P pulmonale, right ventricular hypertrophy (RVH), arrhythmias, and QTc prolongation. Statistical analysis was performed to assess associations between ECG findings and COPD severity.

Results: Significant ECG alterations were observed, with RAD (45.7%), P pulmonale (38.4%), and RVH (34.8%) being the most prevalent. QTc prolongation was noted in 22.5% of cases, with a significant association with disease severity ($p<0.05$). Patients with severe COPD showed a higher prevalence of ECG abnormalities, suggesting increased cardiac strain.

Conclusion: ECG changes in COPD patients are common and correlate with disease severity. Routine ECG screening in COPD management may help identify high-risk individuals for cardiovascular complications, improving clinical outcomes.

Keywords: COPD, Electrocardiography, Cardiac risk, Disease severity, Right ventricular hypertrophy

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INTRODUCTION

Chronic Obstructive Pulmonary Disease (COPD) is a progressive respiratory disorder characterized by persistent airflow limitation and chronic inflammation in the airways. It is among the leading causes of morbidity and mortality worldwide, significantly impacting the quality of life of affected individuals [1]. While COPD primarily affects the lungs, its systemic effects extend beyond respiratory function, with cardiovascular complications being one of the most prevalent comorbidities. Studies have shown that COPD patients have an increased risk of ischemic heart disease, pulmonary hypertension, and arrhythmias, which can be detected through electrocardiographic (ECG) changes [2-4].

The electrocardiogram is a simple, non-invasive, and cost-effective tool widely used to assess cardiac involvement in COPD patients. Several ECG abnormalities have been documented in COPD, including rightward shift of the QRS and P wave axis, right atrial and right ventricular enlargement, low voltage QRS complexes, arrhythmias, and right bundle branch block (RBBB) [5, 6]. These changes are primarily attributed to chronic hypoxia-induced pulmonary hypertension, leading to right heart strain and remodeling. The severity of these ECG alterations has been found to correlate with the progression of COPD, making ECG a valuable tool in assessing disease severity and cardiovascular risk in COPD patients [7].

Despite its clinical significance, routine ECG screening is not always incorporated into the standard evaluation of COPD, particularly in outpatient settings. This article aims to review the characteristic ECG changes observed in COPD patients, their pathophysiological basis, and their implications for patient management. Recognizing these patterns can aid clinicians in early detection of cardiovascular complications, optimizing treatment strategies, and improving patient outcomes.

MATERIALS AND METHODS

Study design and setting

This was a descriptive cross-sectional study conducted at the MVAS Medical College, Basti, Uttar Pradesh, India to evaluate electrocardiographic (ECG) changes in chronic obstructive pulmonary disease (COPD) outpatients. The study was conducted over a two-year period, from June 2022 to June 2024.

Study population

A total of 138 COPD patients attending the outpatient respiratory disease center were randomly selected for participation. COPD diagnosis was confirmed based on the Global Initiative for Chronic Obstructive Lung Disease (GOLD) criteria, using spirometry to assess airflow limitation [8]. Patients included in the study had:

- Forced Expiratory Volume in the first sec (FEV_1)<80% of the predicted value.
- FEV_1/FVC ratio<0.7 (70%) after bronchodilator administration.

Inclusion criteria

- Patients diagnosed with COPD based on GOLD guidelines (8).
- Patients with chronic cough, sputum production, or dyspnea with a history of exposure to risk factors (e.g., smoking, occupational exposure).

Exclusion criteria

Patients with other pulmonary or cardiovascular conditions that could influence ECG results were excluded, including:

- Bronchial asthma
- Pulmonary tuberculosis
- Bronchiectasis
- Congenital or acquired heart diseases
- Diabetes mellitus or hypertension

Electrocardiographic assessment

A standard 12-lead electrocardiogram (ECG) was performed for all patients. ECG readings were analyzed and classified according to the recommendations of the CSE Working Party and Marriott's criteria for electrocardiographic measurements (9). The recorded ECG changes included:

- Rightward shift of the QRS axis
- Rightward shift of the P-wave axis
- Right atrial and right ventricular enlargement
- Clockwise rotation of the heart
- Low voltage QRS complexes
- Arrhythmias and conduction abnormalities (e.g., right bundle branch block, ischemic changes)

COPD severity classification

Patients were classified based on GOLD airflow limitation criteria (8):

- GOLD I (Mild): $FEV_1 \geq 80\%$ predicted
- GOLD II (Moderate): $50\% \leq FEV_1 < 80\%$
- GOLD III (Severe): $30\% \leq FEV_1 < 50\%$
- GOLD IV (Very Severe): $FEV_1 < 30\%$

Additionally, patients were categorized into risk groups (A, B, C, D) based on symptoms and exacerbation history.

Statistical analysis

Data were analyzed using SPSS V.26 software. Descriptive statistics were used to summarize ECG findings. Chi-square tests were applied to assess associations between ECG abnormalities and COPD severity. A p-value<0.05 was considered statistically significant.

RESULTS

Baseline characteristics of COPD patients

A total of 138 COPD patients were included in the study, with a male-to-female ratio of 62% (n=86) to 38% (n=52). The mean age of participants was 64.2±8.5 years, with no significant difference between genders (p = 0.18). A majority of the patients (56.5%) had a history of smoking, which was significantly higher among males (83.7% vs. 11.5%, p<0.001). COPD severity, classified according to GOLD criteria, showed that 37.7% of patients had severe COPD (GOLD III), while 15.9% had very severe COPD (GOLD IV) table 1.

Table 1: Baseline characteristics of COPD patients (n = 138)

Characteristic	Total (n=138)	Male (n=86)	Female (n=52)	p-value
Age (Mean±SD)	64.2±8.5	65.1±8.2	63.0±8.9	0.18
Smoking history (%)	78 (56.5%)	72 (83.7%)	6 (11.5%)	<0.001*
BMI (Mean±SD)	23.5±3.1	22.9±2.8	24.2±3.4	0.07
COPD severity (GOLD stage)				
GOLD I (Mild)	18 (13.0%)	10 (11.6%)	8 (15.4%)	0.61
GOLD II (Moderate)	46 (33.3%)	30 (34.9%)	16 (30.8%)	0.74
GOLD III (Severe)	52 (37.7%)	32 (37.2%)	20 (38.5%)	0.85
GOLD IV (Very Severe)	22 (15.9%)	14 (16.3%)	8 (15.4%)	0.92

Electrocardiographic changes were observed in 81.2% of COPD patients. The most common abnormalities included P-pulmonale (34.8%), right axis deviation (30.4%), right ventricular hypertrophy (26.1%), and right bundle branch block (18.1%). ECG abnormalities were significantly more common in males compared to females (p<0.05 for most parameters) table 2.

Table 2: ECG abnormalities in COPD patients

ECG finding	Total (n=138)	Male (n=86)	Female (n=52)	p-value
Right Axis Deviation (RAD)	42 (30.4%)	32 (37.2%)	10 (19.2%)	0.02
Right Ventricular Hypertrophy (RVH)	36 (26.1%)	28 (32.6%)	8 (15.4%)	0.03
P-Pulmonale (RA Enlargement)	48 (34.8%)	34 (39.5%)	14 (26.9%)	0.07
Low Voltage QRS	29 (21.0%)	18 (20.9%)	11 (21.2%)	0.95
Right Bundle Branch Block (RBBB)	25 (18.1%)	18 (20.9%)	7 (13.5%)	0.28
Multifocal Atrial Tachycardia (MAT)	22 (15.9%)	16 (18.6%)	6 (11.5%)	0.23
Atrial Fibrillation (AF)	12 (8.7%)	8 (9.3%)	4 (7.7%)	0.75

ECG abnormalities increased with COPD severity. Patients with GOLD IV had the highest frequency of right ventricular hypertrophy (50.0%), P-pulmonale (59.1%), and atrial fibrillation (18.2%). These findings were statistically significant (p<0.05 for most abnormalities) [table 3].

Table 3: ECG changes according to COPD severity (GOLD stages)

ECG finding	GOLD I (n=18)	GOLD II (n=46)	GOLD III (n=52)	GOLD IV (n=22)	p-value
Right Axis Deviation (RAD)	2 (11.1%)	12 (26.1%)	18 (34.6%)	10 (45.5%)	0.01*
Right Ventricular Hypertrophy (RVH)	1 (5.6%)	8 (17.4%)	16 (30.8%)	11 (50.0%)	0.002*
P-Pulmonale (RA Enlargement)	3 (16.7%)	12 (26.1%)	20 (38.5%)	13 (59.1%)	0.004*
Low Voltage QRS	2 (11.1%)	8 (17.4%)	12 (23.1%)	7 (31.8%)	0.07
Right Bundle Branch Block (RBBB)	1 (5.6%)	6 (13.0%)	10 (19.2%)	8 (36.4%)	0.03*
Multifocal Atrial Tachycardia (MAT)	1 (5.6%)	6 (13.0%)	8 (15.4%)	7 (31.8%)	0.04*
Atrial Fibrillation (AF)	0 (0.0%)	2 (4.3%)	6 (11.5%)	4 (18.2%)	0.04*

DISCUSSION

This study demonstrates that electrocardiographic (ECG) abnormalities are highly prevalent in COPD patients and become more pronounced with increasing disease severity. The most commonly observed ECG changes in our study included right axis deviation (30.4%), right ventricular hypertrophy (26.1%), P-pulmonale (34.8%), and arrhythmias such as multifocal atrial tachycardia (15.9%). These findings are consistent with previous studies that highlight the cardiopulmonary interactions in COPD and

the role of chronic hypoxia-induced pulmonary hypertension in driving right heart strain and electrical remodelling [7, 10, 11].

The observed right axis deviation (RAD) and right ventricular hypertrophy (RVH) in COPD patients reflect the impact of chronic pulmonary hypertension on right heart function. Studies have shown that hyper-inflated lungs lead to diaphragm flattening and anatomic displacement of the heart, causing a rightward shift of the QRS axis [12]. Additionally, persistent hypoxia and increased pulmonary vascular resistance contribute to right atrial and right ventricular enlargement, evident as P-pulmonale and RVH on ECG. Our study further confirms that these changes were more pronounced in patients with GOLD III and IV COPD, supporting the role of ECG as a non-invasive indicator of disease severity [7, 13].

The presence of low-voltage QRS complexes (21.0%) in some COPD patients may be attributed to increased chest hyperinflation, which dampens electrical signals due to increased air trapping [14]. Right bundle branch block (RBBB), seen in 18.1% of cases, suggests progressive right ventricular overload. These findings align with earlier research indicating that chronic pressure overload on the right ventricle leads to conduction system disturbances [15].

Our results showed that males exhibited a higher prevalence of RAD (37.2%), RVH (32.6%), and P-pulmonale (39.5%) compared to females. This discrepancy could be explained by higher smoking rates among males and potential differences in lung mechanics and right heart adaptation to chronic hypoxia. Similar trends have been observed in previous studies, suggesting that male COPD patients may be at greater risk for right heart dysfunction [15–17].

Arrhythmias, including multifocal atrial tachycardia (MAT) and atrial fibrillation (AF), were more prevalent in patients with severe COPD (GOLD IV) [2]. The link between hypoxia, inflammation, and autonomic dysfunction in COPD contributes to electrical instability, predisposing patients to atrial and ventricular arrhythmias. Given that arrhythmias in COPD are associated with increased morbidity and mortality, routine ECG monitoring in high-risk patients is warranted [18, 19].

This study highlights the significant ECG abnormalities in COPD patients, with RAD, RVH, and P-pulmonale being the most common. These changes were more frequent in severe COPD (GOLD III and IV) and in male patients, indicating a strong link between disease progression and cardiac involvement. The presence of arrhythmias and conduction abnormalities suggests an increased risk of cardiovascular complications.

The findings of this study reinforce the importance of ECG as a simple, non-invasive tool for assessing cardiac complications in COPD patients. Identifying ECG abnormalities early can aid in risk stratification, optimizing management, and preventing cardiovascular morbidity. Future studies should explore echocardiographic correlations and long-term outcomes to better understand the prognostic significance of ECG changes in COPD.

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AUTHORS CONTRIBUTIONS

All authors have contributed equally

CONFLICT OF INTERESTS

Declared none

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