Electrocardiographic Abnormalities in Patients with Severe versus Mild or Moderate Chronic Obstructive Pulmonary Disease Followed in an Academic Outpatient Pulmonary Clinic

Dvorah Holtzman, M.D., Wilbert S. Aronow, M.D., F.A.C.C., F.A.H.A., F.C.C.P., William Michael Mellana, M.D., Mala Sharma, M.D., Nimesh Mehta, M.D., John Lim, M.D., and Dipak Chandy, M.D

From the Cardiology and Pulmonary/Critical Care Medicine Divisions, Department of Medicine, New York Medical College, Valhalla, NY

Background: The prevalence of some electrocardiographic (ECG) abnormalities in severe versus mild or moderate chronic obstructive pulmonary disease (COPD) has been reported.

Methods: ECGs were interpreted blindly in 63 patients with severe COPD (group 1) versus 83 patients with mild or moderate COPD (group 2).

Results: Right atrial enlargement (RAE) occurred in 44% of group 1 and 15% of group 2 patients ($P < 0.001$). Right ventricular hypertrophy (RVH) occurred in 29% of group 1 and 4% of group 2 patients ($P < 0.001$). Right bundle branch block (RBBB) occurred in 29% of group 1 and 11% of group 2 patients ($P < 0.01$). Marked clockwise rotation of heart occurred in 40% of group 1 and 18% of group 2 patients ($P < 0.005$). Low voltage in limb leads occurred in 24% of group 1 and 11% of group 2 patients ($P < 0.05$). A QS pattern in leads III and aVF occurred in 16% of group 1 and 4% of group 2 patients ($P < 0.01$). Left axis deviation (LAD) occurred in 16% of group 1 and 4% of group 2 patients ($P < 0.01$). Premature atrial complexes (PACs) occurred in 19% of group 1 and 7% of group 2 patients ($P < 0.05$). Supraventricular tachyarrhythmias (SVTs) occurred in 16% of group 1 and 5% of group 2 patients ($P < 0.025$).

Conclusions: RAE, RVH, RBBB, marked clockwise rotation of heart, a QS pattern in leads III and aVF, LAD, PACs, and SVTs were significantly more prevalent in patients with severe COPD than in patients with mild or moderate COPD.

Ann Noninvasive Electrocardiol 2011;16(1):30–32

chronic obstructive pulmonary disease; electrocardiogram; right atrial enlargement; right ventricular hypertrophy; right bundle branch block; clockwise rotation of heart

Electrocardiographic (ECG) abnormalities associated with chronic obstructive pulmonary disease (COPD) include right atrial enlargement, right ventricular hypertrophy, right bundle branch block (RBBB), marked clockwise rotation with poor R-wave progression, low voltage in the limb leads, a $S_1S_2S_3$ pattern, a QS pattern in leads III and aVF, right axis deviation, left axis deviation (LAD), sinus tachycardia, premature atrial complexes (PAC), and supraventricular tachyarrhythmias (SVTs).^{1–8} To the best of our knowledge, no previous study

has reported the prevalence of all of these ECG abnormalities in patients with severe COPD versus mild or moderate COPD. This article reports the prevalence of all of these abnormalities and of a normal ECG in 63 patients with severe COPD versus 83 patients with mild or moderate COPD followed in an academic outpatient-pulmonary clinic in a study, in which the ECGs and pulmonary function tests were each analyzed independently by investigators blinded to the results.

Address for Correspondence: Wilbert S. Aronow, M.D., F.A.C.C., F.A.H.A., F.C.C.P., Cardiology and Pulmonary/Critical Care Medicine Divisions, New York Medical College, Macy Pavilion, Room 138, Valhalla, NY 10595. Fax: (914) 235-6274; E-mail: wsaronow@aol.com

Conflicts of interest: None of the authors have any conflicts of interest.

METHODS

The patients included 146 men and women followed in the outpatient pulmonary clinic at Westchester Medical Center/New York Medical College who had COPD diagnosed by pulmonary function tests. ECGs were obtained in these patients. The 146 patients included 79 men and 67 women, mean age 67 ± 11 years.

Severe COPD was diagnosed if the percent predicted forced expiratory volume in 1 second was $<50\%$. Moderate COPD was diagnosed if the percent predicted forced expiratory volume in 1 second was $50\text{--}70\%$. Mild COPD was diagnosed if the percent predicted forced expiratory volume in 1 second was $70\text{--}80\%$. The pulmonary function tests were analyzed by two investigators blindly who were unaware of the ECG results.

The ECGs were analyzed blindly by an experienced electrocardiographer (WSA) who had no knowledge of the pulmonary function tests findings. Right atrial enlargement was diagnosed if the P-wave amplitude in leads II, III, and aVF was ≥ 2.5 mm or if the P wave was upright in lead V₁ with an amplitude ≥ 1.5 mm.¹ Right ventricular hypertrophy (RVH) was diagnosed according to the criteria by Scott et al.⁴ The other ECG abnormalities were diagnosed according to the criteria by Dunn and Lipman.¹

Student's *t*-tests were used to analyze continuous variables. Chi square tests and Fisher's exact tests were used to analyze dichotomous variables.

The institutional review boards of Westchester Medical Center and of New York Medical College approved this study.

Table 1. Baseline Characteristics in Patients with Severe versus Mild or Moderate COPD

	Mild or Moderate COPD (n = 83)	Severe COPD (n = 63)	P-Value
Men	46 (55%)	33 (52%)	NS
Women	37 (45%)	30 (48%)	NS
Age (years)	67 ± 11	68 ± 11	NS

NS: not significant.

RESULTS

Of the 146 patients, severe COPD was present in 63 patients (43%), moderate COPD was present in 65 patients (45%), and mild COPD was present in 18 patients (12%). Table 1 shows the baseline characteristics in patients with severe versus mild or moderate COPD. No significant differences are present.

Table 2 shows the prevalence of the various ECG abnormalities associated with COPD and the prevalence of a normal ECG in patients with severe versus mild or moderate COPD. Table 2 also lists levels of statistical significance.

DISCUSSION

Spodick et al. reported that P-pulmonale was present on the ECG in eight of 20 patients (40%) with severe COPD and in 34 of 281 patients (11%) with mild or moderate COPD.² Calatayud et al. reported that P-pulmonale was present in 80 of 173 patients (46%) with COPD.⁶ In the present study, right atrial enlargement was present on the

Table 2. Prevalence of ECG Abnormalities Associated with COPD in Patients with Severe versus Mild or Moderate COPD

Variable	Mild or Moderate COPD (n = 83)	Severe COPD (n = 63)	P-Value
Right atrial enlargement	12 (15%)	28 (44%)	<0.001
Right ventricular hypertrophy	3 (4%)	18 (29%)	<0.001
Complete RBBB	9 (11%)	18 (29%)	<0.01
Marked clockwise rotation	15 (18%)	25 (40%)	<0.005
Low voltage in limb leads	9 (11%)	15 (24%)	<0.05
S ₁ S ₂ S ₃ pattern	3 (4%)	6 (10%)	NS
QS in leads III and aVF	3 (4%)	10 (16%)	<0.01
Right axis deviation	1 (1%)	4 (6%)	NS
LAD	3 (4%)	10 (16%)	<0.01
Sinus tachycardia	4 (5%)	6 (10%)	NS
PAC	6 (7%)	12 (19%)	<0.05
SVTs	4 (5%)	10 (16%)	<0.025
Normal electrocardiogram	33 (40%)	12 (19%)	<0.01

NS: not significant; SVTs: atrial fibrillation or atrial flutter or paroxysmal atrial tachycardia.

ECG in 28 of 63 patients (44%) with severe COPD versus 12 of 83 patients (15%) with mild or moderate COPD ($P < 0.001$).

Scott et al. reported that RVH was present on the ECG in eight of 28 patients (29%) with severe COPD.⁴ Silver and Calatayud reported that RVH diagnosed by an R/S ratio in lead V_6 of ≤ 1.0 was present on the ECG in 28 of 43 patients (65%) with severe COPD versus 13 of 122 patients (11%) with mild or moderate COPD.⁷ In the present study, RVH was present in 18 of 63 patients (29%) with severe COPD versus three of 83 patients (4%) with mild or moderate COPD ($P < 0.001$).

Scott et al. reported that complete or incomplete RBBB was present on the ECG in nine of 28 patients (32%) with severe COPD.⁴ In the present study, RBBB was present on the ECG in 18 of 29 patients (29%) with severe COPD versus nine of 83 patients (11%) with mild or moderate COPD ($P < 0.01$).

Zuckermann et al.⁵ reported that marked clockwise rotation with poor R-wave progression was present on the ECG in 30 of 50 patients (60%) with severe COPD.⁵ In the present study, marked clockwise rotation with poor R-wave progression was present on the ECG in 25 of 63 patients (40%) with severe COPD versus 15 of 83 patients (18%) with mild or moderate COPD ($P < 0.005$). The present study also showed that low voltage in the limb leads ($P < 0.05$), a QS pattern in leads III and aVF ($P < 0.01$), LAD ($P < 0.01$), PAC ($P < 0.05$), and SVTs ($P < 0.025$) were significantly more prevalent in patients with severe COPD than in patients with mild or moderate COPD.

Spodick et al. reported that a normal ECG was present in four of 20 patients (20%) with severe COPD versus 79 of 281 patients (28%) with mild or moderate COPD.² In the present study, a normal ECG was present in 12 of 63 patients (19%) with severe COPD versus 33 of 83 patients (40%) with mild or moderate COPD ($P < 0.01$).

Shah et al. reported that 19 of 20 patients (95%) with COPD versus two of 19 patients (11%) with restrictive lung disease ($P < 0.001$) had a vertical P-wave axis between $+70^\circ$ and $+90^\circ$.⁹ Vertical P-wave axes corresponded to low-diaphragm levels

(rib/interspace 10.5 to 12.5).⁹ Because the right atrium is carried by attachments to the right diaphragmatic leaf, the resultant positional effects on the right atrium most likely cause or contribute to the significantly different P-axis orientations in COPD versus restrictive lung disease.⁹ A vertical P-wave axis is a useful screening test for COPD with a sensitivity of 89% and a specificity of 96% reported.¹⁰

In patients clinically suspected of having COPD, we found that ECG evidence of right atrial enlargement, right ventricular hypertrophy, complete RBBB, marked clockwise rotation, low voltage in the limb leads, a QS complex in leads III and aVF, LAD, PAC, and SVTs were significantly more prevalent in patients with severe COPD than in patients with mild or moderate COPD. The greater the number of these ECG abnormalities, the more likely the patient has severe COPD.

REFERENCES

1. Dunn MI, Lipman BS. Lipman-Massie Clinical Echocardiography, 8th edition. Chicago, Year Book Medical Publishers, Inc., 1989.
2. Spodick DH, Hauger-Klevene JH, Tyler JM, et al. The electrocardiogram in pulmonary emphysema. Relationship of characteristic electrocardiographic findings to severity of disease as measured by degree of obstruction. *Amer Rev Resp Dis* 1963;88:14-19.
3. Rodman DM, Lowenstein SR, Rodman T. The electrocardiogram in chronic obstructive pulmonary disease. *J Emerg Med* 1990;8:607-615.
4. Scott RC, Kaplan S, Fowler NO, et al. The electrocardiographic pattern of right ventricular hypertrophy in chronic cor pulmonale. *Circulation* 1955;11:927-936.
5. Zuckermann R, Cabrera E, Fishleder BL, et al. Electrocardiogram in chronic cor pulmonale. *Amer Heart J* 1948;35:421-437.
6. Calatayud JB, Abad JM, Khoi NB, et al. P-wave changes in chronic obstructive pulmonary disease. *Amer Heart J* 1970;79:444-453.
7. Silver HM, Calatayud JB. Evaluation of QRS criteria in patients with chronic obstructive pulmonary disease. *Chest* 1971;59:153-159.
8. Scott RC. The electrocardiogram in pulmonary emphysema and chronic cor pulmonale. *Amer Heart J* 1961;61:843-845.
9. Shah NS, Koller SM, Janower ML, et al. Diaphragm levels as determinants of P axis in restrictive versus obstructive pulmonary disease. *Chest* 1995;107:697-700.
10. Baljepally R, Spodick DH. Electrocardiographic screening for emphysema: The frontal plane P axis. *Clin Cardiol* 1999;22:226-228.