

## Electrocardiographic and Echocardiographic Changes among the Patients of COPD in a Teaching Hospital

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Chronic Obstructive Pulmonary Disease (COPD) is a major cause of chronic morbidity and mortality throughout the world. Pulmonary arterial hypertension is the major cardiovascular complication of COPD. Right ventricular (RV) dysfunction occurs in up to 50% of the patients with moderate to severe COPD. This study was undertaken to study the electrocardiographic and echocardiographic changes in COPD patients with different grades of severity of the disease, as assessed clinically and through pulmonary function testing. Further, an attempt has been made to compare the electrocardiographic and the echocardiographic changes, with respect to duration and severity of the disease and to see which of them is a better predictor of right ventricular dysfunction in COPD. This is a Cross sectional study done in Department of Medicine, Rajshahi Medical College Hospital, Rajshahi from January, 2012- June, 2012. During the study period a total of 70 patients were studied with age limitation 40-70 years. COPD patients who fulfilled inclusion criteria were included in this study. All the patients were investigated with spirometry, ECG and echocardiography. In this study 70(100%), 48(68.57%), 27(38.57%) had dyspnoea, cough with / without sputum, leg oedema respectively. 48.57% patients (34/70) of the patients had ECG evidence of RVH. Right axis deviation was present in all the patient of RVH. Cor-pulmonale was diagnosed clinically 35.71%, by ECG 48.57%, and by Echocardiography 52.86%. The frequency of ECG and Echo findings increases with the severity and duration of the disease. So echocardiography is better than ECG or clinical methods, to detect the presence of cor pulmonale in patients with COPD.

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**Key words:** COPD, ECG, Echocardiography, Cor-pulmonale

### Introduction

Chronic obstructive pulmonary Disease (COPD) is currently the 4th leading cause of death in the world and further increases in its prevalence and mortality can be predicted in the coming decades. COPD accounts for a substantial number of visits to general physician, emergency department, hospital admissions, and also a cause for frequent absence from work. The global

initiative for chronic obstructive lung disease, defines COPD as a disease state characterized by airflow limitation that is not fully reversible. The airflow limitation is usually both progressive and associated with an abnormal inflammatory response of the lungs to noxious particles or gases.<sup>1</sup> Many previous definitions of COPD have emphasized the terms emphysema and chronic bronchitis,

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which are no longer included in the definition of COPD used in GOLD report<sup>1</sup>. Emphysema or destruction of gas exchanging surfaces of lung (alveoli) is a pathological term that is often (but incorrectly) used clinically, and describes only one of the several structural abnormalities present in patients with COPD.<sup>1</sup> Chronic bronchitis, defined as the presence of cough and sputum production for at least 3 months in each of 2 consecutive years, remains a clinically and epidemiologically useful term. According to GOLD report, a diagnosis of COPD should be considered in any patient who has symptoms of cough, sputum production, or dyspnoea, and / or history of exposure to risk factors for the disease. The diagnosis is confirmed by spirometry. Spirometric classification of COPD based on post bronchodilator FEV1 was done in the following way.<sup>1</sup>

Stage I: Mild	FEV1/FVC < 0.70 FEV1 ≥ 80% predicted
Stage II: Moderate	FEV1/FVC < 0.70 50% ≤ FEV1 < 80% predicted
Stage III: Severe	FEV1/FVC < 0.70 30% ≤ FEV1 < 50% predicted
Stage IV: Very Severe	FEV1/FVC < 0.70 FEV1 < 30% predicted or FEV1 < 50% predicted plus chronic respiratory failure.

Risk factors for COPD include both host factors ( $\alpha$ -1 Antitrypsin deficiency, Airway hyper responsiveness, Lung growth) and environmental exposures (Tobacco smoke, Occupational dust and chemicals, Indoor and outdoor air pollution, Infection, Socio-economic status).<sup>2</sup> The true incidence of cor pulmonale in COPD has been difficult to establish. Earlier studies of prognostic indicators in patients with COPD reported cor pulmonale in about 25% of all subjects<sup>3</sup>.

However, cor pulmonale in these studies was determined by clinical or ECG criteria that are insensitive predictors of RV dysfunction in patients with COPD. More sensitive diagnostic techniques have found RV dysfunction in up to half the patients with moderate to severe COPD.<sup>3</sup> Pulmonary arterial hypertension is its major cardiovascular complication.<sup>3</sup> Right ventricular dysfunction occurs in up to 50% of the patients with moderate to severe COPD.<sup>4</sup> Early recognition and treatment of right ventricular dysfunction may lead to prolonged survival and improved quality of life. Cor pulmonale is defined as right ventricular hypertrophy and dilation secondary to pulmonary hypertension caused by diseases of the lung parenchyma and / or pulmonary vasculature, unrelated to the left side of the heart. Chronic obstructive pulmonary disease is by far the main cause of cor pulmonale.<sup>5</sup>

The earliest recognition of a rather distinct ECG pattern in chronic cor pulmonale is credited to Zuckermann et al who thought that this clinical state could frequently be entertained by electrocardiographic survey before it could be by routine clinical methods<sup>6</sup>. The electrocardiographic features of right ventricular hypertrophy were described by Myers G. B. and Klein H. A. et al<sup>7</sup> in 1948. Many others put forward their set of electrocardiographic criteria for R.V. hypertrophy, and almost all of them included.

1. Right axis deviation of QRS ( $> 110^\circ$ )<sup>2,8,9,10,11,12</sup>
2. R/s amplitude ratio in V1  $> 1$ .<sup>2,8,11</sup>
3. R/s in V6  $< 1$ <sup>2,8,9,10,13</sup>
4. P  $> 3$  mm in standard leads<sup>11</sup>
5. T wave inversion in V1 to V3<sup>11</sup>
6. S1 Q3 pattern and S1, S2, S3 pattern<sup>13</sup>

In 1989, V. K. Singh and S. K. Jain studied electrocardiographic features of COPD

patients in relation to their lung function tests and found that there was a significant correlation between the degree of air flow limitation and incidence of various ECG features suggestive of right ventricular involvement.<sup>14</sup> In 1975 Stephen and Richard showed that pulmonary artery pressure and pulmonary vascular resistance could be evaluated by echocardiographic assessment and thus reduced necessity for repeated cardiac catheterization.<sup>15</sup> In 1981 Prakash R in his study found that echocardiographic measurements of right ventricular wall thickness are useful in the diagnosis of RV hypertrophy and are more sensitive than ECG criteria in adults.<sup>16</sup> In 1982, Tomi Watanabe et al evaluated applicability of 2-dimensional echocardiography to right ventricular volume determination and compared it with angiographic measurements and concluded that estimation of right ventricular volume and morphology with 2-D echocardiography is an excellent non-invasive method available in clinical practice to evaluate right ventricular volume and morphology.<sup>17</sup> In 1982 Starting and Crawford et al described a new 2-dimensional echo technique for evaluating right ventricular size and performance in patients with COPD.<sup>18</sup> Putnik and Povazan in 1998, in their study to evaluate the possibilities of echocardiography and electrocardiography in establishing the diagnosis of chronic pulmonary heart disease, concluded that echocardiography had better sensitivity than electrocardiography, and both methods have an important role in examining cardiac changes in patients with COPD.<sup>19</sup> Thus from the above studies, it is clear that 2-dimensional echocardiographic assessment of right ventricular dimensions can be a valuable tool in early detection of right ventricular dysfunction in COPD patients.

### Methods

It is a cross-sectional type of descriptive study done in Department of Medicine, Rajshahi

Medical College Hospital, Rajshahi from January, 2012- June, 2012. 70 patients were studied through purposive sampling method. During the study period a total of 70 patients were studied with age limitation 40-70 years. COPD patients who fulfilled inclusion criteria were included in this study. Each subject was administered a pre-designed questionnaire. Complete history and physical examination was done and recorded in a case record form by the investigator himself. ECG & echocardiography were done to observe changes. Spirometry was performed. The data was analyzed with the help of SPSS software program version- 16.0 descriptive analytical techniques involving frequency distribution computation of percentage, mean SD etc. was applied.

### Results

Total number of Stable COPD patients attending in Medicine OPD of Rajshahi Medical College Hospital, in the period Jan-July 2012 was 316. Out of this 154 were COPD cases. Out of these cases 70 cases were randomly selected those which met the inclusion and exclusion criteria. The mean age was 58.94 ( $\pm 10.37$ ) years, range 40-70 years. The maximum incidence of COPD in this study is among the age group 50-59 years i.e. in the 5<sup>th</sup> and 6<sup>th</sup> decade (47.14%). The mean duration of symptoms was 4.71 ( $\pm 4.98$ ) years, range 1 to 10 years. Maximum number of patients (60%) had symptoms of 1-5 years of duration, and patients in more than 10 years of symptoms were only 10%. The mean FEV1 was 36.01 ( $\pm 12.23$ ) % of predicted, range 17 to 60 % of predicted. Maximum number of patients (55.71%) had severe airflow obstruction at the time of presentation and only 4.29% had mild disease. Majority of the patients had history of tobacco exposure of at least 20-29 pack years (40%). Majority of the patients with severe disease (25.71% i.e., 18/70 patients) had history of 20-29 pack years of tobacco exposure. All patients in this

study had history of breathlessness at presentation. 68.57% of the patients had cough with sputum at presentation. 38.57% of the patients presented with oedema. The most common sign at presentation is tachypnea 70% followed by epigastric pulsation(54.28%) . 28.57% of the patients had loud P2 suggestive of pulmonary hypertension. 30% of the patients had parasternal heave, the clinical evidence of right ventricular hypertrophy. 22.85% of the patients had cyanosis which is evidence of a hypoxic state. Regarding X-ray 80% of the patients had feature of emphysema. 62.85% of the patients had increased bronchovascular markings suggestive of chronic bronchitis. X-ray evidence of pulmonary hypertension i.e. prominent pulmonary conus / prominent right descending pulmonary artery (> 16 mm) was present in 30% of the patients. Cardiomegaly on X-ray was present in 20%. Electrocardiography shows P pulmonale 33(47.13%), Low voltage complexes 19(25.71%), Poor progression of r waves 22(30%). Regarding conduction block five patient had incomplete RBBB (7.14%). In this study 34(48.57%) of the patients had ECG evidence of right ventricular hypertrophy. The most common RVH criteria in these patients was right axis deviation, present in 100% of patients RVH, followed by R/S in V5/6 <1 in 82.35%, followed by R/S in V1 >1 in 61.76 % . In the mild category one patient had low voltage complex and another one had poor progression of “r” wave. In the moderate category, 32.14% of the patients had RAD and RVH. In the moderate category, 39.28% of the patients had ‘p’ pulmonale. In the severe category 82.05% of the patient had ECG changes (i.e. 32/39) , 64.1% (25/39) had right axis deviation and all the patient of RAD had evidence of right ventricular hypertrophy. In severe category P-pulmonale was present in 56.41% of patients. The most common ECG finding in patients within 1-5 years of duration was p-pulmonale (45.23%,

i.e. 19/42) , 40.48%(i.e. 17/42) of the patients in 1-5 years group had ECG evidence of RVH, 52.38%(i.e. 11/21) of the patients in 6-10 year group had ECG evidence of RVH, 85.71% (i.e. 6/7) of the patients in > 10 year duration group had ECG evidence of RVH, 19.04%(i.e. 4/21) of the patients in 6-10 year group had incomplete right bundle branch block and 28.6%(i.e. 2/7) in > 10 year group had incomplete RBBB. In this study 52.86% of the patients had echocardiographic evidence of cor pulmonale, 57.14% of the patients had echocardiographic evidence of pulmonary hypertension, 28.57% of the patients had right ventricular dilatation and 47.14% patients had right ventricular hypertrophy, 14.28% of the patients had echocardiographic features of RV failure , 37.14% of the patients had right atrial dilatation, 38.09% (i.e. 16/42) of the patients in the 1-5 year duration group had echo evidence of cor-pulmonale, 71.42%(i.e. 15/21) of the patients in 6-10 years group had echo evidence of cor pulmonale and in patients with > 10 years of symptoms 85.71%(i.e. 6/7) of them had cor-pulmonale. The frequency of occurrence of pulmonary hypertension echocardiographically in 1-5, 6-10 and > 10 years groups were 45.23%, 71.42% and 85.71% respectively. Echocardiographic evidence of R.V. failure was present in 9.52%, 19.04% and 28.57% of 1-5, 6-10 and > 10 years groups respectively. In the mild group only one patient had echo evidence of pulmonary hypertension and no patient had evidence of cor pulmonale. In the moderate group, 25% (i.e. 7/28) of the patients had echocardiography evidence of pulmonary hypertension and 25% (i.e. 7/28) had evidence of cor pulmonale. In the severe group, 82.05 % (i.e. 32/39) of the patients had echo evidence of pulmonary hypertension, and 76.92%(i.e. 30/39) had echocardiographic evidence of cor pulmonale. Only in the severe group 25.64% (i.e. 10/39) of the patients had echo evidence of R. V. failure.

Table I: Relationship between ECG findings with severity the of COPD

ECG Findings	Mild (n=3)		Moderate (n=28)		Severe (n=39)	
	No	(%)	No	(%)	No	(%)
'p' pulmonale	0	0	11	39.28	22	56.41
Low voltage complex	1	33.3	5	17.86	13	33.33
Right axis deviation	0	0	9	32.14	25	64.10
Poor 'r' wave progression	1	33.3	7	25.00	14	35.89
Incomplete RBBB	0	0	0	00	5	12.80
RVH	0	0	9	32.14	25	64.10

Table II: Relationship between ECG findings with duration of Symptoms

ECG Findings	1-5 Yrs (n=42)		6-10 Yrs (n=21)		> 10 Yrs (n=7)	
	No	(%)	No	(%)	No	(%)
'p' pulmonale	19	45.23	9	42.85	6	85.71
Low voltage complex	12	28.57	8	38.09	2	28.60
Right axis deviation	17	40.48	15	71.42	6	85.71
Poor 'r' wave progression	13	30.95	9	42.85	2	28.60
In complete RBBB	0	00	4	19.04	2	28.60
RVH	17	40.48	11	52.38	6	85.71

Table III: Relationship between echocardiography findings with duration of disease

Echo Findings	1-5 Yrs (n=42)		6-10 Yrs (n=21)		> 10 Yrs (n=7)	
	No	(%)	No	(%)	No	(%)
R. A. dilatation	13	30.95	9	42.85	4	57.14
R.V. dilatation	09	21.42	04	19.04	7	100.00
R.V. wall hypertrophy	13	30.95	14	66.66	6	85.71
R.V. failure	4	9.52	4	19.04	2	28.57
Cor. Pulmonale	16	38.09	15	71.42	6	85.71
Pulmonary hypertension	19	45.23	15	71.42	6	85.71

Table IV: Relationship between echocardiographic findings with severity of the disease

Echo Findings	Mild (n=3)		Moderate (n=28)		Severe (n=39)	
	No	(%)	No	(%)	No	(%)
R. A. dilatation	1	33.33	5	17.85	20	51.28
R.V. dilatation	0	00	3	7.50	17	43.58
R.V. wall hypertrophy	1	33.33	6	15.00	26	66.66
R.V. failure	0	00	0	00	10	25.64
Cor. Pulmonale	0	00	7	25.00	30	76.92
Pulmonary hypertension	1	33.33	7	25.00	32	82.05

### Discussion

The maximum numbers of COPD patients (33/70) in this study were in the age group of 50-59 years with mean age 58.94 ( $\pm 10.37$ ) years, which is similar to previous studies. Comparison with other studies Putnik and Povazan,<sup>19</sup> 59.25 yrs, Burrows et al,<sup>20</sup> 56.5 $\pm$ 7.4 yrs, Keller & Shepard et al,<sup>21</sup> 59 $\pm$ 7 yrs. In this study most of the patients (42/70) gave history of symptoms of 1-5 years

duration, with a mean duration of dyspnoea and cough of 5.71 years. In the study conducted by Gupta et al,<sup>22</sup> the mean duration of symptoms was 8.9±4.9 years and in the study of J. C. Banergae,<sup>23</sup> the mean duration of cough was 5.4 yrs and dyspnoea was 1.94 years. In this study, majority of the patients (28/70) had a history of tobacco use of at least 20-29 pack-years, with a mean of 23.2 years (±3.6). And according to BTS guide lines most patients with COPD have at least in 20 pack years of smoking history<sup>24</sup>. Our finding correlates well with this. And the annual decline in FEV1 in smokers is nearly double, that of non-smokers and the findings 71.79% of the patients with severe disease had more than 20 pack years of exposure correlates with this. In the study by Gupta and Khastgir<sup>22</sup> mean of 26.4 (±16.1) pack years of smoking history was found, which is similar to the present study. In the present study, 55.71% (39/70) of the patients had FEV1 < 40% of the predicted i.e. severe obstructive disease. Only 4.29% of the patients are in mild category, in this study. Comparison with other studies Gupta & Khastgir,<sup>22</sup> Higham et al,<sup>3</sup> showed that Mild disease was 1(3.48%) and 12(16.4%), moderate diseases was 5(17.2%) and 19(26%), severe disease was 23(79.3%) and 42(57.6%) respectively. Present study showed that Mean FEV<sub>1</sub> (SD) (% of predicted) was 36.01% (±12.23) which is very similar with Keller et al,<sup>21</sup> 33 (±14) and M.A. Higham et al<sup>3</sup> 39.4(±19.7). Almost all the patients had breathlessness and cough with sputum on presentation. J. C. Banergae<sup>23</sup> showed that 73(97.3%) had Dyspnoea, 69(92%) had Cough with / without sputum, 63(84%) had Oedema. This study also showed that 70(100%), 48(68.57%), 27(38.57%) had Dyspnoea, Cough with / without sputum, Oedema respectively. Clinical signs of right ventricular hypertrophy were present in 30% (21/70) of the patients and pulmonary hypertension in 28.57% (20/70) of the patients. Gupta & Khastgir<sup>22</sup>

showed that 30(100%), 15(50%), 30(100%), 15(50%), 17(57%) had Tachypnoea, Cyanosis, Epigastric pulsation, Parasternal heave and Loud P2 respectively. The higher incidence of most of the signs of RVH and pulmonary hypertension and CHF in the study by Gupta and Khastgir<sup>22</sup> can be explained by the fact that their study included nearly 80% of the patients with severe disease (38% of the patients with FEV1 <20) % of predicted signifying advanced disease and only 17% of patients with moderate disease (FEV1 40-59%) of predicted compared to 36% in the present study. In this study 48.57% (34/70) of the patients had ECG evidence of RVH, with criteria used as given by Braunwald<sup>25</sup>. The incidence of RVH by ECG varies in different studies, depending on the number of patients in cor pulmonale in the study, and the criteria used by the authors. Our findings correlate with the findings of F.J.C. Millard<sup>10</sup> (45.7%) and Murphy and Hutcheson<sup>13</sup> (43.66%) and Gupta and Khastgir<sup>22</sup> (50%). Right axis deviation was present in 48.57% (34/70) of the patients in the present study and in 100% (34/34) of the patients with RVH. According to Murphy & Hutcheson,<sup>13</sup> right axis deviation is one of the most reliable criteria of RVH, and is more common in patients with RVH secondary to COPD than in those with RVH secondary to congenital heart disease and has a specificity of 95%. Millard<sup>10</sup> concluded that in chronic pulmonary disease, the position of mean QRS axis provided as good an indication of right ventricular hypertrophy as any other electrocardiographic sign. Other studies, Roman<sup>2</sup> and Phillips<sup>26</sup> also emphasized the value of right axis deviation as a sign of RVH. Our findings are in agreement with the above studies. Regarding R> 7mm in V<sub>1</sub> Comparison with other studies

Author	Incidence (%)
Silver et al, <sup>09</sup>	21.00
Murphy et al, <sup>13</sup>	9.40
Folwer et al, <sup>27</sup>	7.00
Padmavathi et al, <sup>28</sup>	2.60
Present study	15.71

The incidence of R>7 mm in V1 ranges from 2.6% - 21% and the finding of 15.71 % in this study is well within this range.

Regarding Incomplete RBBB Comparison with other studies

Author	Incidence (%)
Murphy et al, <sup>13</sup>	3.00
Padmavathi et al, <sup>28</sup>	12.90
K. K. Datey et al, <sup>32</sup>	6.00
Present study	7.14

Caird and Wilcken<sup>30</sup> state that, incomplete RBBB is considered by some as good evidence of the presence of RVH but not of its degree. Phillips and Burch<sup>31</sup> have included these criteria among the fairly conclusive criteria for RVH.

The findings of p-pulmonale in this study (47.13%) is similar to Silver et al (46.2%),<sup>9</sup> Gupta and Khastgir<sup>22</sup> (43.3%).

Regarding Low voltage complexes Comparison with other studies

Author	Incidence (%)
Calatayud et al, <sup>09</sup>	29.00
Murphy et al, <sup>13</sup>	58.50
Fowler et al, <sup>27</sup>	40.00
Padmavathi et al, <sup>28</sup>	41.00
Present study	25.71

Regarding Poor progression of 'r' wave Comparison with other studies

Author	Incidence (%)
Fowler et al <sup>27</sup>	27.00
Padamavathi et al <sup>28</sup>	17.20
Present study	30.00

This finding is also due to changes in the position of the heart due to pulmonary emphysema. In the present study, 52.86% (37/70) of the patients had echocardiographic evidence of cor pulmonale, comprising of R. V. dilatation, R. V. hypertrophy, R. A. dilatation or evidence of R. V. failure.

Echo finding	Himelmann, et al <sup>33</sup> (%)	Present study (%)
R. V. dilatation	55	28.57
R. A. enlargement	39	37.14
R. V. hypertrophy	25	47.14
Pulmonary hypertension	49	57.14
Cor pulmonale	75	52.86

All the echocardiographic findings generally showed an increasing trend in the incidences, with increasing duration of symptoms. This can be explained by the fact that longer the duration of the disease, higher is the chances that the patient has developed pulmonary hypertension and cor pulmonale and also right heart failure.

ECG criteria for detecting right ventricular hypertrophy, have a reasonably high specificity (86-96%) but relatively low sensitivity (38-63%). Many studies have proved that echocardiography is more sensitive than electrocardiography in detecting R. V. dysfunction in COPD. Prakash R<sup>16</sup> in his study found that ECG had a sensitivity of 31% and Specificity of 85% and ECHO had a sensitivity of 93% and specificity of 95% in detecting RV dysfunction. Putnik<sup>19</sup> in his study found that diagnosis of cor-pulmonale by ECG could be made in 78% and by ECHO in 95% of the patients. Himelmann<sup>33</sup> in his study found that cor-pulmonale could be diagnosed in 39% of

the patients by clinical methods and by echocardiography in 75%. Oswald mammoser<sup>34</sup> found that sensitivity and specificity for diagnosis of pulmonary hypertension in patients with COPD by ECG was 51% and 86% respectively and by Echo was 78% and 78% respectively. Thus the findings in the present study fairly correlate with the above studies. In this study the diagnosis of cor-pulmonale could be made in 35.71% by clinical method, 48.57% by electrocardiographic method and 52.86% by echocardiographic method. This clearly shows that echocardiography is better than ECG or clinical methods, to detect the presence of cor pulmonale in patients with COPD.

#### *Conclusion*

COPD is more common in males and in the 5th and 6th decade. Most of the patients have fairly advanced disease at presentation. Echocardiography and ECG are better than clinical methods in detecting RV dysfunction in COPD. The incidence of Echocardiography and ECG findings are more common as the disease duration and severity increases. Echocardiography is better than ECG in the diagnosis of RV dysfunction in COPD

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