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Echocardiographic evaluation of right heart in chronic obstructive pulmonary disease patients

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Abstract

Background: Chronic obstructive pulmonary disease (COPD), defined by GOLD as a preventable and treatable disease with some significant extrapulmonary effects, is a very common clinical entity in clinical practice. Echocardiography evaluation mainly focused on effects on the right heart function is a salient tool to evaluate the presence of degree of pulmonary hypertension and also identify that group of patients who need more early aggressive therapy for the underlying lung disease. We aimed to prospectively study the patients with diagnosed COPD with echocardiogram for evaluating the right heart.

Methods: An observational cross sectional, single centre study was done on 100 patients with COPD who were admitted in Mymensingh Medical College Hospital and underwent echocardiographic evaluation from January to December 2022. All echocardiographic parameters focused on right heart and its function were assessed.

Results: Total 100 COPD patients studied, majority of patients should be male (64 patients, 64%) with the mean age of 60.9 ± 11.4 years. Ninety Four patients (94%) studied had significant ECG abnormality out of which P 'pulmonale' was the most common (90 patients, 90%) while atrial arrhythmias in the form of Atrial fibrillation (AF) or Multifocal tachycardia (MAT) (12 patients, 12%) being the least common finding. Pulmonary hypertension defined as $sPAP > 30$ mmHg was evident in all of the patients; with 30 patients (30%), 50 (50%) and 20 (20%) patients having severe, moderate and mild pulmonary hypertension respectively. RV dysfunction was evident with reduced average TAPSE values (1.59 ± 0.38 cm) and elevated RIMP values (0.58 ± 0.16).

Conclusion: Majority of COPD patients had evidence of pulmonary hypertension. Echocardiogram can be a helpful tool to assess early changes on the right heart size and function in patients with COPD and also monitor these patients for rapid progression of the illness.

Keywords: Prevalence, COPD, pulmonary hypertension, RV dysfunction

Introduction

Chronic obstructive pulmonary disease (COPD), defined by GOLD as a preventable and treatable disease with some significant extrapulmonary effects, is a very common clinical entity in clinical practice. COPD is a leading cause of death and disability worldwide. According to World Health Organization (WHO) data it is expected to move from its status in 2000 as the 4th and 12th most frequent cause of mortality and morbidity, respectively, to the 3rd and 5th leading cause of mortality and morbidity, respectively, in 2020^[1, 2]. COPD is associated with significant extrapulmonary (systemic) effects among which cardiac manifestations are most common. COPD is currently the 4th leading cause of death in the world and a burning problem among the Bangladesh population. COPD affects pulmonary blood vessels, right ventricle, as well as left ventricle leading to development of pulmonary hypertension, cor pulmonale, right ventricular dysfunction, and left ventricular dysfunction^[3]. Right ventricle (RV) dysfunction is common in patients with COPD particularly in those with low oxygen saturation. Cardiovascular disease accounts for approximately 50% of all hospitalization and nearly one third of all deaths, if forced expiratory volume in one second (FEV_1) > 50% of predicted^[4].

In more advanced disease cardiovascular disease account for 20%-25% of all deaths in COPD [5]. Echocardiography provides a rapid, noninvasive portable and accurate method to evaluate the right ventricle function, right ventricular filling pressure, tricuspid regurgitation, left ventricular function and valvular function [6]. Pulmonary hypertension (PH) affects the right ventricle function leading to cor pulmonale and once developed these patients have poor prognosis. So, the early recognition of RV dysfunction and pulmonary hypertension may help in treatment and prolonging the survival of the patients with cor pulmonale. Echocardiography provides a rapid, noninvasive method to evaluate the right ventricle chamber size and function [7].

Materials and Methods

An observational cross sectional, single centre study was done on 100 patients with COPD who were admitted in Mymensingh Medical College Hospital and underwent echocardiographic evaluation from January to December 2022. All selected patients were subjected to routine investigations, including complete blood count, lipid profile, blood sugar, CRP, blood urea, serum creatinine, electrocardiography, and so on, as needed.

The inclusion and exclusion criteria were as follows:

Inclusion criteria

All COPD patients attending the echocardiography laboratory.

Exclusion criteria

1. Patients who cannot lie for long enough to complete the study.
2. H/O of diagnosed chronic lung disease other than COPD like - Interstitial lung disease, Old pulmonary TB with sequelae.
3. Any systemic disease that can cause pulmonary hypertension,
4. Patients with congenital heart disease, rheumatic heart disease, valvular heart disease, ischemic heart disease and cardiomyopathy.

All necessary parameters for RV function by echocardiography were calculated and analysed. Parameters measured include RV and right atrial (RA) size, measure of RV systolic function, as assessed by at least one or a combination of the following: DTI-derived tricuspid lateral annular systolic velocity wave (S'), tricuspid annular plane systolic excursion (TAPSE), and RV index of myocardial performance (RIMP). RV systolic pressure was calculated using the tricuspid regurgitation jet and an estimation of RA pressure based on inferior vena cava (IVC) size and collapsibility. Hence, pulmonary artery systolic pressure (PASP) was calculated by using continuous wave Doppler and applying the equation below: $PASP = 4V^2$ (peak TR velocity) $2 + RAP$ IVC diameter < 2.1 cm that collapses $> 50\%$ with a sniff suggests normal RA pressure of 3 mm Hg (range, 0–5 mm Hg), whereas IVC diameter > 2.1 cm that collapses $< 50\%$ with a sniff suggests high RA pressure of 15 mm Hg (range, 10–20 mm Hg). In scenarios in which IVC diameter and collapse do not fit this paradigm, an intermediate value of 8 mm Hg (range, 5–10 mm Hg) was used [8]. TAPSE measures predominantly the longitudinal systolic function and values < 17 mm is highly suggestive of RV systolic dysfunction. Right atrium pressure can be estimated with the IVC diameter and its changes with respiration. The calculations were done by Microsoft Excel 2010, and Statistical Package for Social Sciences, SPSS version 20; and the data were presented in the form of tables and diagrams. Appropriate statistical tests were carried out to compare the data, and a level of significance of 0.05 was used. Values were expressed as Mean \pm standard deviation.

Results

Total 100 COPD patients studied, majority of patients should be male (64 patients, 64%) with the mean age of 60.9 ± 11.4 years. Ninety Four patients (94%) studied had significant ECG abnormality out of which P 'pulmonale was the most common (90 patients, 90%) while atrial arrhythmias in the form of Atrial fibrillation (AF) or Multifocal tachycardia (MAT) (12 patients, 12%) being the least common finding (Table 1).

Table 1: ECG abnormalities in COPD patients (n=100)

Characteristics	Male (n=64)	Female(n=36)	Overall (n=100)	p value
ECG abnormalities	62 (96.9%)	32 (88.9%)	94 (94%)	> 0.05
P ' pulmonale	58 (90.6%)	32 (88.9%)	90 (90%)	> 0.05
R/S ratio				
> 1	40 (37.5%)	24 (62.7%)	62 (62%)	> 0.05
< 1	24 (37.5%)	12 (33.3%)	36 (36%)	> 0.05
RBBB	24 (37.5%)	14 (38.9%)	38 (38%)	> 0.05
AF/MAT	10 (15.6%)	2 (5.6%)	12 (12%)	> 0.05

Echocardiography done in the studied patients showed evidence of varying degrees of pulmonary hypertension along with enlargement of right sided chambers of the heart. Tricuspid regurgitation peak gradient a useful marker for indirect evidence of pulmonary hypertension was studied in all the patients. Pulmonary hypertension defined as sPAP (Peak systolic pulmonary pressure) value > 30 mmHg was observed in all of the patients in the study group. The mean TRPG value studied was 63.76 ± 20.57 mmHg with the range of 26-100 mmHg and their corresponding peak systolic pulmonary artery pressure (PASP) mean value was

75.26 ± 21.18 mmHg. Among patients with evidence of pulmonary hypertension, 30 patients (30%) had severe PAH, 50 patients (50%) had moderate PH and 20 patients (20%) had mild degree of pulmonary hypertension as shown in Table 2. Other parameters of right heart enlargement and function such as RA area, RV base and mid diameter, TAPSE, RIMP, S' were studied. The mean RV diameters were increased as compared to normal adult values and parameters for RV function like TAPSE and RIMP also showed that majority of patients had significant RV dysfunction in our study (Table 3).

Table 2: Pulmonary hypertension Grade (n=100)

Pulmonary hypertension	Numbers	Percentage
Mild (>30-50mmHg)	20	20%
Moderate (>50-70mmHg)	50	50%
Severe (>70 mmHg)	30	30%

Table 3: Echocardiographic RV parameters (n=100)

	Range	Mean
RA Area (cm ²)	8.8-39	20.57±6.8
RV diameter (base) /cm	3.6-6.8	5.04±0.66
RV diameter (mid) /cm	3.4-6.8	4.68±0.58
RV wall thickness /cm	0.5-1.1	0.77±0.11
TAPSE /cm	0.9-2.3	1.59±0.38
TDI s' /cm/s	6.7-19	11.5±2.95
RV MPI	0.35-0.98	0.58±0.16
TRPG /mmHg	26-110	63.76±20.57
PASP	36-120	75.26±21.18

Inferior venacava diameter (IVCd) at diastole is a surrogate marker for increased right atrial pressure and is useful for estimation of peak pulmonary artery pressure. The mean IVC diameter was 1.88±0.35 cm as shown in (Table 4).

Table 4: Echocardiographic LV parameters and IVC size (n=100)

LVDD /cm	2.8-5.7	4.01±0.64
LVSD/cm	1.5-4.5	2.48±0.63
IVS/cm	0.6-1.1	0.79±0.09
PW/cm	0.6-1.2	0.82±0.01
EF%	50-65	60.34±3.89
IVC d/cm	1-2.4	1.88±0.35

*LVID – LV internal diastole diameter, LVSD- LV systole diameter, IVS – Interventricular septum, PW- Posterior wall thickness, EF – Ejection fraction.

Discussion

The perspective of COPD has changed significantly over the past two decades. We have moved from an airflow limitation (FEV1)-centric view of the disease to the realization that COPD is a complex and heterogeneous condition [1, 9]. Pulmonary artery remodeling is observed early in COPD and leads to pulmonary artery hypertension (PAH). Most of the increased mortality associated with COPD is due to cardiac involvement. Echocardiography provides a rapid, noninvasive, portable, and accurate method to evaluate the cardiac changes. The cardiac manifestations of COPD are numerous. Impairment of RV function and alteration of pulmonary blood vessels are well known to complicate the clinical course of COPD and correlate inversely with survival. Long term changes with chronic pulmonary vascular remodeling and vasoconstriction impose increase in RV afterload and ultimately result in RV dilation and later dysfunction manifesting as cor pulmonale. Total 100 COPD patients studied, majority of patients should be male (64 patients, 64%) with the mean age of 60.9±11.4 years. Ninety Four patients (94%) studied had significant ECG abnormality out of which P ‘pulmonale’ was the most common (90 patients, 90%) while atrial arrhythmias in the form of Atrial fibrillation (AF) or Multifocal tachycardia (MAT) (12 patients, 12%) being the least common finding. Although the true prevalence of PH in COPD is unknown, an elevation of pulmonary arterial pressure is reported to occur in 20%–90% of patients when measured by right heart catheterization [10]. The level of PH has a prognostic value in COPD patients that has been

demonstrated by several studies. In one of these studies, the 5-year survival rates were 50% in patients with mild PH (30-50 mmHg), 30% in those with moderate to severe PH (50-70 mmHg), and 0% in the small group of patients with very severe PH (>70 mmHg). Thus, a high degree of PH bears a poor prognosis in patients with COPD and this also has been observed in COPD patients receiving long-term oxygen therapy [11]. In our study, all 100 patients had evidence of pulmonary hypertension (sPAP> 30 mmHg) with majority of them (60%) having higher grades of pulmonary hypertension maybe because of the chronicity of the disease and the study was mainly done in admitted patients with COPD. There were significant evidence of right ventricular enlargement as well as decline in RV systolic function through various parameters studied by echocardiography. All COPD patients studied had shown an increase in RV enlargement in form of increased RV diameters (RV base = 5.04±0.66 and RV mid = 4.68±0.58 cm). RV systolic function as assessed by TAPSE and RIMP also showed values below normal adult population values which indicate majority of COPD patients studied had evidence of RV dysfunction as well. (TAPSE, mean = 1.59±0.38, RIMP = 0.58±0.16). Saxena N *et al* [12]. Showed tricuspid annular systolic velocity (TAPSE) is a useful measurement in determining right ventricular systolic function regardless of pulmonary artery pressures in a study of 52 patients. Evidence of right ventricular hypertrophy was also seen in most patients with the average RV wall thickness of 0.77±0.11 mm as compared to normal adult value of 3-5 mm. These results indicate that further large scale studies using a more accurate assessment method for PH are warranted, to achieve a more detailed assessment of the RV dysfunction associated with COPD. Echocardiographic evaluation of right heart can be used as an important risk assessment tool for assessing RV function and pulmonary artery pressure and should constitute part of a periodic screening tool for all COPD patients. Regular cardiac monitoring by echo in these COPD patients can help to identify individuals at risk of increased morbidity and mortality, warranting close monitoring and aggressive treatment to prevent or delay complications. The exact correlation to the severity of pulmonary hypertension with pulmonary function test of patients with each COPD patients also could not be done. So, a lot of COPD patients with mild to moderate form were not included which made a bias that higher group demonstrated severe form of pulmonary hypertension. These findings suggest an important role of echocardiographic parameters of RV function in COPD prognosis. Though this study was relatively small in size, this correlation between COPD prognosis and RV function on echocardiography has not been studied extensively in the past. Echocardiography is relatively cheaper and noninvasive modality which is readily available and can immensely help in prognostication of these patients. There is a need of larger future studies in this direction.

Conclusion

This study reveals that chronic obstructive pulmonary disease with pulmonary hypertension is highly prevalent in Bangladesh population. Echocardiographic right heart profile assessment should be an additional tool to detect and prognosticate patients with various degrees of pulmonary hypertension.

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