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Original Article

# Echocardiographic Right Heart in Patients with Chronic Obstructive Pulmonary Disease

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***ABSTRACT***

***Introduction:*** *COPD is one of the most common causes of death and disability worldwide. Chronic obstructive pulmonary disease (COPD) is highly prevalent among the Bangladeshi population. We aimed to prospectively study patients diagnosed with COPD using echocardiography to evaluate their right heart function.* ***Methods & Materials:*** *An observational, cross-sectional study was done on 60 patients with COPD who were admitted at Department of Cardiology, M Abdur Rahim Medical College Hospital, Dinajpur, Bangladesh and underwent echocardiographic evaluation from January 2023 to June 2023. All echocardiographic parameters related to the right heart and its function were evaluated.* ***Results:*** *Out of total 60 COPD patients studied, majority of them were female (38 patients, 63.3%). The mean age of the patients studied was 60.9 years, with a standard deviation of 11.4 years. Pulmonary hypertension defined as sPAP>30 mmHg was evident in all of the patients; with 36 patients (60%), 17 (28.3%) and 7 (11.6 %) 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:*** *The majority of patients with COPD showed signs 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:*** *COPD, Pulmonary Hypertension, RV Dysfunction*

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## INTRODUCTION

COPD leads to structural and mechanical changes in the pulmonary vascular bed, increasing right ventricular (RV) afterload and contributing to right heart failure. This exacerbates outcomes and elevates the risk of rehospitalization and death[1-3]. Evaluating right ventricular function is important for COPD patients, as right ventricular dysfunction affects their prognosis[4,5]. Right heart hypertrophy and diastolic dysfunction are linked to limited exercise capacity and poor prognosis[5]. While invasive hemodynamic measurement of right ventricular (RV) function by cardiac catheterization remains the gold standard, recent studies have increasingly focused on noninvasive assessment of pulmonary hypertension (PH) and RV function using cardiac magnetic resonance imaging (CMR). In one of these studies, the change in right ventricular mass index and the pulmonary artery cross-sectional area was utilized to estimate the mean pulmonary artery pressure[6]. Right ventricular (RV) dysfunction is common in COPD patients, especially those with low oxygen saturation. Pulmonary hypertension (PH) impairs right ventricle function and causes it. Once developed, the prognosis of these patients is poor. Early detection of right ventricular dysfunction and pulmonary hypertension can aid in treatment and extend the survival of patients with lung disease. Echocardiography is a quick, noninvasive method for assessing right ventricular size and function[7]. A study using cardiovascular magnetic resonance (CMR) found that pulmonary artery pulsatility and acceleration time were reduced in patients with chronic obstructive pulmonary disease (COPD)[8]. CMR has also been used to distinguish between arrhythmogenic RV cardiomyopathy and RV changes in athlete's heart[9]. COPD is associated with significant extrapulmonary (systemic) effects, of which cardiac symptoms are the most common. Cardiovascular disease accounts for approximately 50% of all hospitalizations and nearly one-third of all deaths when forced expiratory volume in one second ($FEV_1$) is greater than 50% of the predicted value[3]. In more advanced stages of the disease, cardiovascular issues account for 20% to 25% of all deaths in patients with COPD (Chronic Obstructive Pulmonary Disease)[4]. COPD affects the pulmonary blood vessels and both the right and left ventricles, leading to the development of pulmonary hypertension, cor pulmonale, right ventricular dysfunction, and left ventricular dysfunction. Echocardiography offers a quick, noninvasive, portable, and accurate method to assess right ventricular function, filling pressures, tricuspid regurgitation, left ventricular function, and valvular function[5]. These parameters are highly correlated with the RVEF measured using magnetic resonance imaging[10,11]. Currently, literature remains limited regarding the assessment of these parameters in predicting outcomes for COPD patients.

## METHODS & MATERIALS

This observational, cross-sectional study was conducted on 60 patients with Chronic Obstructive Pulmonary Disease (COPD) who were admitted to the Department of

Cardiology at M. Abdur Rahim Medical College Hospital in Dinajpur, Bangladesh. The study took place from January 2023 to June 2023 and involved echocardiographic evaluations focusing on the right heart and its function. Informed consent was obtained from all patients prior to their recruitment into the study.

**Inclusion criteria:**

- All patients with Chronic Obstructive Pulmonary Disease (COPD) who visited the echocardiography laboratory at Bir Hospital during the study period.

**Exclusion criteria:**

- Patients who cannot lie for long enough to complete the study
- History of diagnosed chronic lung disease, excluding COPD, such as interstitial lung disease and old pulmonary tuberculosis with sequelae.
- Any systemic disease that has the potential to cause pulmonary hypertension.
- Patients who have been diagnosed with congenital heart disease, rheumatic heart disease, or valvular heart disease.

All necessary parameters for assessing right ventricular (RV) function via echocardiography were calculated and analyzed. The measured parameters include the sizes of the RV and the right atrium (RA) as well as indicators of RV systolic function. These indicators were determined using at least one or a combination of the following methods: Doppler tissue imaging (DTI)-derived tricuspid lateral annular systolic velocity wave (S'), tricuspid annular plane systolic excursion (TAPSE), and the RV index of myocardial performance (RIMP).

RV systolic pressure was estimated using the tricuspid regurgitation jet along with an estimation of RA pressure based on the size and collapsibility of the inferior vena cava (IVC). If the IVC diameter and collapse do not fit this model, a standard intermediate value of 8 mm Hg (with a range of 5–10 mm Hg) was applied. TAPSE primarily assesses longitudinal systolic function, with values below 17 mm being highly suggestive of RV systolic dysfunction. Additionally, right atrial pressure can be estimated by measuring the IVC diameter and observing its changes with respiration.

The calculations were done by Microsoft Excel 2010, and Statistical Package for Social Sciences, SPSS version 21; and the data were presented in the form of tables and diagrams. Statistical tests were appropriately conducted to compare the data, using a significance level of $p$=0.05. Values are presented as mean ± standard deviation.

## RESULTS

Total 60 patients included in our study. Among 63.3% (n=38) were female with the mean age of 60.9 ±11.4 years. 54 patients (90%) studied had significant ECG abnormality out of which P 'pulmonale was the most common (54 patients, 90 %) while atrial arrhythmias in the form of Atrial fibrillation (AF) or Multifocal tachycardia (MAT) (7 patients, 11.6 %) being the least common finding (**Table I**).

**Table I: ECG abnormalities in COPD patients**

| Characteristics | Male *n*=22(%) | Female *n*=38(%) | Overall *n*=60(%) | *p*-value |
|---|---|---|---|---|
| ECG abnormalities | 19 (86.3) | 37 (97.3%) | 56 (93.3%) | > 0.05 |
| P 'pulmonale | 20 (90.9) | 34 (89.4%) | 54 (90%) | > 0.05 |
| **R/S ratio** | | | | |
| >1 | 15 (68.1) | 23 (60.5%) | 38 (63.3 %) | > 0.05 |
| < 1 | 7 (31.8) | 15 (39.4%) | 22 (36.6%) | >0.05 |
| RBBB | 8 (36.3) | 15 (39.4 %) | 23 (38.3%) | > 0.05 |
| AF/MAT | 1 (4.5) | 6 (15.7%) | 7 (11.6%) | >0.05 |

Echocardiography performed on the studied patients indicated varying degrees of pulmonary hypertension and enlargement of the right-sided chambers of the heart. The mean TRPG value studied was 63.76 ±20.57mmHg 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, 36 patients (60%) had severe PAH, 17 patients (28.4%) had moderate PH and 7 patients (11.6%) had mild degree of pulmonary hypertension as shown in **Table II**.

**Table II: Pulmonary hypertension Grade**

| Pulmonary hypertension | Numbers | Percentage |
|---|---|---|
| Mild(>30-50mmHg) | 7 | 11.6% |
| Moderate (>50-70) | 17 | 28.4% |
| Severe (>70 mmHg) | 36 | 60% |

Other parameters of right heart enlargement and function such as RA area, RV base and mean diameter, TAPSE, RIMP, S' were examined. The mean RV diameter in adults was increased compared to normal values, and RV function parameters such as TAPSE and RIMP also showed that the majority of patients in this study had significant RV dysfunction (**Table III**).

**Table III: Echocardiographic RV parameters**

| | Range | Mean±SD |
|---|---|---|
| RA Area (cm2) | 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 |

The inferior vena cava diameter in diastolic (IVCd) is a surrogate marker of elevated right atrial pressure and helps in estimating peak pulmonary artery pressure. The mean diameter of the inferior vena cava (IVC) was measured at 1.88 ± 0.35 cm, as shown in **Table IV.**

**Table IV: Echocardiogrpahic LV parameters and IVC size**

| | **Range** | **Mean** |
|---|---|---|
| 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 |
| IVCd/cm | 1-2.4 | 1.88±0.35 |

## DISCUSSION

Our understanding of COPD has changed significantly over the past 20 years. We have evolved from a view of the disease centered on airflow limitation (FEV1) to the realization that COPD is a complex and heterogeneous disease[12]. In early COPD, pulmonary arterial remodeling is observed, leading to pulmonary arterial hypertension (PAH). This remodeling is the result of endothelial dysfunction and coagulopathy. Pulmonary-specific mechanisms such as hypoxic vasoconstriction, destruction of the pulmonary capillary bed due to emphysema, inflammatory infiltration of the vascular wall due to smoking, and shear stress caused by blood flow redistribution contribute significantly to the development of PAH in COPD patients[13]. Impaired RV function and pulmonary vascular changes are known to complicate the clinical course of COPD and are inversely correlated with survival. Long-term changes involving chronic pulmonary vascular remodeling and vasoconstriction require increased RV afterload, which ultimately leads to RV dilation and dysfunction that later manifests as pulmonary function. The presence of PAH indicates a poor prognosis in COPD patients, as several studies have correlated elevated PAP with worse survival[14]. For a long time, interest in cardiac ultrasound among pulmonologists and cardiologists was limited to the evaluation of RVSP in COPD patients. Therefore, in this study, we looked beyond RVSP and investigated the correlation of different parameters of RV systolic function with COPD severity and mid-term outcome. Although the true prevalence of PH in

COPD is unknown, it has been reported that 20–90% of patients experience elevated pulmonary artery pressure as measured by right heart catheterization[15]. 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 (20–30 mmHg), 30% in those with moderate to severe PH (30–50 mmHg), and 0% in the small group of patients with very severe PH (>50 mmHg). A high level of PH indicates a poor prognosis in COPD patients, including those receiving long-term oxygen therapy[16]. In this study, all 60 patients showed evidence of pulmonary hypertension, defined as a systolic pulmonary artery pressure (sPAP) greater than 30 mmHg. The majority of the patients (60%) had more severe grades of pulmonary hypertension, likely due to the chronic nature of the disease, as the study primarily involved patients with chronic obstructive pulmonary disease (COPD) who were hospitalized. Significant evidence of right ventricular enlargement was observed, along with a decline in right ventricular (RV) systolic function, as assessed through various echocardiographic parameters. 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). The assessment of RV systolic function using TAPSE and RIMP indicated values below normal for the adult population, suggesting that most COPD patients studied exhibited signs of RV dysfunction. (TAPSE, mean = 1.59 ±0.38, RIMP = 0.58±0.16). A study conducted by *Saxena N et al.* 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[17]. 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 suggest that further large-scale studies using more accurate methods of evaluation of PH are justified to achieve a more detailed assessment of right ventricular dysfunction associated with COPD. An accurate correlation between the severity of pulmonary hypertension and the patients' pulmonary function tests could also not be established for each individual COPD patient. Thus, many patients with mild to moderate COPD were not included, resulting in a bias in that the upper group had more severe pulmonary hypertension.

## CONCLUSION

This study reveals that chronic obstructive pulmonary disease with pulmonary hypertension is highly prevalent in Bangladeshi population. Significant prevalence of right heart dysfunction is seen in COPD and hence, COPD patients should be subject to right heart evaluation by echocardiography so that treatment modalities can be modified to reduce morbidity and mortality. Echocardiographic right heart profile assessment should be an additional tool to detect and

prognosticate patients with various degrees of pulmonary hypertension.

**Conflict of Interest:** None.
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