

Cardiac evaluation of patients with chronic obstructive pulmonary disease using echocardiography

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Background Chronic obstructive pulmonary disease (COPD) is a significant cause of death. Cardiovascular disease is a significant cause of morbidity and mortality in COPD.

Aim We used echocardiography to evaluate cardiac function in patients with COPD and correlated echocardiographic findings with COPD severity.

Patients and methods We performed a prospective cross-sectional study on 60 patients with stable COPD who presented to the Abbasia Chest Hospital during the period from November 2016 till August 2017. Spirometry was performed for all participants using American and European Thoracic Society (2005) recommendations. They were classified according to GOLD guidelines (2017) and evaluated by two-dimensional Doppler echocardiography according to American and European Association of Echocardiography ASE recommendations.

Results Echocardiographic examination of left ventricular functions revealed no cases of left ventricular systolic dysfunction, but left ventricular diastolic dysfunction was found in ~25%. Right ventricle dilatation was found in ~18% of the patients. Tricuspid regurgitation was seen in ~75%, with variable grades from mild to severe. Pulmonary hypertension (PH) was found in ~40% of the patients. It was more prevalent

in patients with severe and very severe disease. Correlation between echocardiographic findings and severity of COPD revealed significant positive correlation only with right ventricle size, tricuspid regurgitation, and PH.

Conclusion Left ventricular diastolic dysfunction appears to be frequent in patients with COPD, but it is not related to the disease severity. Abnormal right heart changes could be expected. Presence of PH has a linear relationship with COPD severity.

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Introduction

Chronic obstructive pulmonary disease (COPD) is expected to be the third leading cause of mortality in 2020 [1].

Association between cardiovascular disease and COPD can be explained by many risk factors [2], including cigarette smoking [3], systemic effect of the inflammation [4], impaired vascular function, and hyperinflation of the lungs [5].

Echocardiography is an easy, noninvasive method for evaluation of changes of the heart secondary to COPD [6].

This study aimed to evaluate cardiac function by echocardiography in patients with COPD and correlated echocardiographic findings with COPD severity.

Patients and methods

We performed a prospective cross-sectional study on 60 patients with stable COPD who presented to the Abbasia Chest Hospital during the period from November 2016 till August 2017.

We excluded patients with other chronic lung diseases than COPD, systemic hypertension, any primary heart disease, and any disease that causes pulmonary hypertension (PH), as well as patients with severe COPD having respiratory failure and patients who could not undergo spirometric test.

We based on history, physical examination, chest radiography, and that post bronchodilator ratio of forced expiratory volume in 1st sec (FEV1) to vital capacity is less than 0.7 to diagnose COPD according to GOLD guidelines 2017. Ratio was measured by spirometry (3500 Spirometer; Viasys Micro Lab., England) with consideration of recommendations of American Thoracic Society/European thoracic society (2005) [7].

We classified severity of COPD according to FEV1% of predicted as follows: mild (FEV1 \geq 80% of

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predicted), moderate ($50\% \leq FEV1 < 80\%$ predicted), severe ($30\% \leq FEV1 < 50\%$ predicted), and very severe ($FEV1 < 30\%$ predicted) [1].

Two-dimensional transthoracic, M-mode, and Doppler echocardiography examination was done for all patients by Siemens SONOLINE G60 S system (Siemens, USA), and a transducer array of 4–2 MHz.

We measured all parameters with American Society and European Association of Echocardiography recommendations [8]. All parameters were measured at end expiration as follows: we used M-mode and two-dimensional techniques to assess left ventricular ejection fraction and dimension techniques in short-axis and long-axis left parasternal views. We measured peak velocity of early diastolic flow (E), peak velocity of atrial contraction (A), and their ratio (E/A) to evaluate left ventricular diastolic function. We measured them over the mitral valve in apical four-chamber view with color flow imaging for optimal alignment of pulsed wave Doppler with blood flow. Right ventricular (RV) size was assessed by measurement of right internal mid-cavity dimension in apical four-chamber view. We measured tricuspid annular plane systolic excursion (TAPSE) in apical four-chamber view to assess RV systolic function. We used color flow Doppler technique to identify tricuspid regurgitation flow and continuous wave Doppler for measurement of the maximum jet velocity. The modified Bernoulli equation was used to estimate right ventricular systolic pressure (RVSP). Bossone *et al.* [9] consider RVSP to be equal to the systolic pulmonary artery pressure (sPAP): $sPAP \text{ (mmHg)} = RVSP = \text{trans-tricuspid pressure gradient} + \text{right atrial pressure}$. Right atrial pressure was predicted by using the inferior vena cava size and collapsibility index. We defined PH as sPAP more than or equal to 35 mmHg [10].

Our study was approved by local ethical committee of scientific research.

Statistical analysis

We used IBM statistical analysis of social sciences statistics software (version 22.0, 2013; IBM Corp., Chicago, Illinois, USA), for statistical analysis. We used descriptive statistics for normally distributed quantitative data such as minimum and maximum range with mean \pm SD and for qualitative ones, number and percentage.

We used independent *t* test in cases of two independent groups with normally distributed data for quantitative variables, and for analysis of qualitative data, we used

inferential analyses for independent variables. χ^2 test was used for differences between proportions, and Fisher's exact test for variables with small expected numbers. Pearson's correlation was used for qualitative data and partial correlation test for controlling age. We considered that level of significance at *P* value less than 0.050 is significant, and more than that value is not significant.

Results

Our study included 56 (93.3%) males and four (6.7%) females, with mean age of 58.4 ± 7.7 years, ranging from 40 to 79 years old.

Most patients had severe to very severe obstruction. Demographic characteristics and spirometric results of our cases are shown in Table 1.

Echocardiographic examination of left ventricular systolic functions revealed mild to moderate left ventricular dimensions dilatation in $\sim 35\%$ of patients, whereas mild impairment of systolic function of left ventricle was seen in $\sim 28\%$ of patients, but no cases of left ventricular systolic dysfunction (LVSD) (ejection fraction $< 40\%$) were detected.

However, left ventricular diastolic dysfunction (LVDD) measured by E/A ratio was seen in $\sim 25\%$ of the patients.

Motion wall abnormalities were not found in the patients of this study.

Table 1 Demographic characteristics and spirometric results of the studied cases

Variables	Mean \pm SD	Range
Age (years)	58.4 \pm 7.7	40.0–79.0
Sex [n (%)]		
Male	56 (93.3)	
Female	4 (6.7)	
Occupation [n (%)]		
Manual	52 (86.7)	
Official	8 (13.3)	
Smoking [n (%)]		
Never	7 (11.7)	
Exsmoker	6 (10.0)	
Current	47 (78.3)	
FEV1/FVC	54.6 \pm 11.2	30.0–70.0
FEV1%	48.6 \pm 18.1	24.0–86.0
Obstruction [n (%)]		
Mild	7 (11.7)	
Moderate	17 (28.3)	
Severe	28 (46.7)	
Very severe	8 (13.3)	

FEV1, forced expiratory volume in 1 s; FVC, forced vital capacity.

RV examination revealed RV dilatation in ~18% of the patients. Tricuspid regurgitation was found in ~75%, with variable grades from mild to severe, with positive correlation between grades of obstruction and tricuspid regurgitation. TAPSE was normal in all patients.

PH was found in ~40% of patients. It appeared more in severe and very severe grades of COPD than in mild/moderate grades (55.7 and 16.7%, respectively). Most of the patients (30%) who developed PH had mild degree of PH (35–49 mmHg).

Correlation between respiratory functions and echocardiography findings revealed a statistically significant negative correlation between FEV1 and FEV1/forced vital capacity ratio and RV size and RVSP, that is, when FEV1 and FEV1/forced vital capacity ratio decrease, RV size, and RVSP increase (Table 2).

Discussion

COPD is considered a worldwide cause of chronic morbidity and mortality [1]. Patients with COPD have a high risk of cardiovascular disease, and it can be a cause of their death [11,12].

COPD can affect pulmonary blood vessels, right side of the heart, and may affect left side of the heart [13,14].

Echocardiographic changes seen in patients with COPD were studied and correlated with severity of the disease.

The current study found that there were no cases with LVSD, ejection fraction less than 40%. However, the

presence of mild LVSD was seen in ~28% of patients, whereas mild to moderate left ventricular dimensions dilated in ~35%.

True prevalence of LVSD is unknown. It varies widely, from 0 to 25%, as reported by Portillo *et al.* [15], who stated that the prevalence may depend on selecting patients with or without coronary artery disease, the presence or absence of associated PH, and airflow obstruction degree.

In the current study, no motion wall abnormalities were found in the echo findings of the patients.

This disagreed with Freixa *et al.* [16] who found that 30% of patients with LVSD presented left ventricle wall motion abnormalities. This difference might be owing to a large number of included patients.

In current study, no statistical significant correlation was found between left ventricular systolic function and dimensions and the severity of COPD. This is similar to Freixa *et al.* [16].

Frequent reports about the prevalence of LVDD in patients with COPD have been shown in many studies. The prevalence of LVDD in this study was ~25%. This was in contrary to Huang and colleagues, who showed a higher frequency of LVDD in patients with COPD (65.6%) and Caram and colleagues who reported high frequency up to 88%. Another study by López-Sánchez *et al.* [19] focused on severe COPD outpatients and showed a highest prevalence of LVDD (90%) [17,18].

The difference in the frequency of LVDD in patients with COPD between this study and previous studies might be owing to the difference of inclusion criteria such as different age group, absence of comorbidities, and unavailability of tissue Doppler echocardiography, which made the detection of diastolic dysfunction more accurate.

In this study, there was no correlation between LVDD and the severity of COPD. This is similar to the study conducted by Huang *et al.* [17].

The current study showed that RV dilatation was found in early stages of COPD. This agreed with Hilde *et al.* [20].

Moreover, there was a positive correlation between severity of COPD and RV size. This is similar to the study conducted by Jatav *et al.* [21].

Table 2 Correlation between respiratory functions and echocardiography findings

Variables	FEV1/FVC		FEV1	
	<i>r</i>	<i>P</i>	<i>r</i>	<i>P</i>
Age ^a	-0.397	0.002*	-0.413	0.001*
LVF ^b	-0.241	0.066	-0.108	0.415
LVDD ^b	0.095	0.475	0.095	0.476
LVDs ^b	0.228	0.079	0.146	0.265
RV size ^b	-0.257	0.050*	-0.251	0.050*
RVSP ^b	-0.391	0.002*	-0.353	0.006*
TAPSE ^b	0.222	0.091	0.055	0.681
E/A ^b	0.035	0.790	-0.020	0.882

E/A, peak velocity of early diastolic flow (E), peak velocity of atrial contraction (A), and their ratio (E/A); FEV1, forced expiratory volume in 1 s; FVC, forced vital capacity; LVDD, left ventricular internal dimension diastolic dimension (mm); LVDs, left ventricular internal systolic dimension (mm); LVF, left ventricular function; RV, right ventricle; RVSP, right ventricular systolic pressure; TAPSE, tricuspid annular plane systolic excursion. ^aPearson's correlation. ^bPartial correlation (controlled for age). *Significant.

In the present study, tricuspid regurgitation was present in ~75% of the patients with variable grades from mild to severe. There was a positive correlation between grades of obstruction and tricuspid regurg. Similar findings were observed in study of Maula *et al.* [22]. True prevalence of PH in COPD is unknown. A reported elevation of pulmonary arterial pressure is between 20 and 90% measured by right heart catheterization, with some evidence that PH increases with increase airflow obstruction [14,23,24]. The current study showed that the presence of PH, that is, pulmonary artery systolic pressure more than 35 mmHg, was 40%. PH appeared more in severe and very severe grades of the disease than in mild/moderate disease.

These results agreed with Jatav *et al.* [21] and El Wahsh *et al.* [25] who showed that increased pulmonary artery systolic pressure was found in 44 and 55.56% of patients, respectively, and also showed a positive correlation with severity of COPD.

Most of the patients (30%) in the current study with PH had mild degree of PH, and this was in agreement with Freixa *et al.* [16] who found that the magnitude of PH was mild in most cases and only 3% of patients had severe PH.

In the current study, TAPSE was used as easily obtainable measure of RV systolic function, and it was normal in all patients, which is in contrary to Hilde *et al.* [20] who included some patients with COPD with very severe degree of obstruction with respiratory failure and TAPSE was lower in them than controls.

In this study, there were some limitation such as using two-dimensional Doppler echocardiogram with color flow without using tissue Doppler echocardiography, which made the assessment of prevalence of LVDD less accurate. Right heart catheterization was not available for definitive diagnosis of PH and detection of its prevalence.

Conclusion

LVDD appears to be frequent in patients with COPD but it is not related to the disease severity. Abnormal right heart changes could be expected. Prevalence of PH has a linear relationship with severity of COPD.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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