International Journal of Medical Arts

Volume 4, Issue 3, March 2022

https://ijma.journals.ekb.eg/

Print ISSN: 2636-4174

Online ISSN: 2682-3780

Available online at Journal Website
https://ijma.journals.ekb.eg/
Main Subject [Internal Medicine]

Original Article

Echocardiographic Abnormalities in Obstructive Airway Disease

Ibrahim Shalan [1*]; Mohamed Mahmoud [2]; Yassin Abd-Elkareem Galal [1]; Hytham Abdallah Abdelmaksound [1]; Mohamed Rashad Mohamed [1]

[1] Department of Chest Diseases, Faculty of Medicine, Al-Azhar University, Assiut, Egypt.

[2] Department of Cardiology, Faculty of Medicine, Al-Azhar University, Assiut, Egypt.

Article information

Received: 8-01-2022

Accepted: 28-03-2022

DOI: 10.21608/ijma.2022.231305

*Corresponding author

Email: ishalan99@yahoo.com

Citation: Shalan I, Mahmoud M, Galal YA, Abdelmaksound HA, Mohamed MR. Echocardiographic Abnormalities in Obstructive Airway Disease. JMA 2022 March; 4 [3]: 2252-2257. doi: 10.21608/ijma.2022.231305

ABSTRACT

Background: Obstructive airway disease is a common condition with airflow limitation due to exposure to exposure to noxious agents. Its main characteristics are the preventable and treatable nature of the disease. It includes bronchial asthma and chronic obstructive pulmonary disease [COPD]. COPD is a major cause of mortality, and associated cardiovascular abnormalities are suggested as the cause of morbidity and mortality.

The Aim of The work: The current study aimed to evaluate the cardiac dysfunctions in COPD by echocardiography.

Patients and Methods: This work included 60 patients with stable COPD who presented at Chest Diseases Department, Al-Azhar University Hospital [Assiut] from December 2018 till October 2020. All were submitted to Spirometry. Then, they were classified according to The Global Initiative for Chronic Obstructive Lung Disease [GOLD] guidelines [2019]. Then cardiac evaluation was performed by echocardiography.

Results: Left ventricle [LV] systolic dysfunction did not discovered in any of the studied patient. However, LV diastolic dysfunction was reported in 30%. In addition, 16.6% had right ventricle dilatation, and 71.7% had tricuspid regurge of different grades; the majority were of moderate grade. Furthermore, 56.0% had pulmonary hypertension. However, the majority of them were of mild degree. Its higher incidence was associated with severe and very severe COPD disease. Finally, there was a significant proportional correlation between disease severity and echocardiographic data, mainly size of the right ventricle, tricuspid regurgitation and pulmonary hypertension.

Conclusion: LV diastolic dysfunction is frequent in COPD. However, it is not related to the COPD disease severity. The main abnormalities were of the right heart. Pulmonary hypertension when present has a linear relationship with disease severity.

Keywords: The Global Initiative for Chronic Obstructive Lung Disease; Cardiac; Echocardiography; Obstructive Airway Disease; Pulmonary Hypertension.

INTRODUCTION

Obstructive airway disease is a common condition, which include main chronic obstructive pulmonary disease [COPD] and bronchial asthma. It is associated with significant morbidity and mortality. COPD is a preventable and treatable condition of air flow limitations and persistent symptoms. The condition caused by significant exposure to noxious substances. The process of airflow limitation, the main characteristic of COPD is due to obstructive bronchiolitis and emphysema [1].

COPD is the third leading cause of respiratory morbidity and mortality all over the globe [2], and cardiac disease is responsible for about 50.0% of COPD hospitalization and 20% of COPD-related deaths [3].

Many risk factors could explain the link between COPD and cardiovascular disease. These include smoking, impaired function of the vascular beds, systemic inflammation and lung hyperinflation [4]. COPD could affect the pulmonary vasculatures, which reflected on the right ventricle, as well as left ventricle, with subsequent development of pulmonary hypertension [PH], and cor pulmonale [5].

Echocardiography is an easy, readily available, noninvasive modality for evaluation of the cardiac changes in respiratory obstructive diseases [6]. The early diagnosis of pathological cardiovascular changes in obstructive airway disease give the chance for early intervention and prevention of progress to irreversible condition. The use of echocardiography could provide a simplest and accurate way for early diagnosis. However, no sufficient studies evaluate the role of such modality in COPD.

THE AIM OF THE STUDY

This study aimed to assess cardiac dysfunctions in chronic obstructive pulmonary disease [COPD] by echocardiography.

PATIENTS AND METHODS

Sixty patients with confirmed clinical, radiological spirometric diagnosis of COPD, who were presented to the Department of Chest Diseases, Al-Azhar University Hospital [Assiut], were included in the study. They were selected during duration from December 2018 till October 2020.

Exclusion criteria: Patients who cannot lie for enough duration to complete the study; other chronic lung diseases than COPD [e.g., interstitial lung disease, and pulmonary tuberculosis [TB]], systemic hypertension, any primary heart disease, and any disease lead to the development of pulmonary hypertension, as well as severe COPD with respiratory failure.

The diagnosis was based on history, physical examination, chest radiography, and post-bronchodilator ratio of forced expiratory volume in the first second [FEV1] to vital capacity [VC] was < 0.7, according to GOLD guidelines 2019. Ratio was measured by spirometry, [smartSOFTmee, England] with consideration of recommendations of American Thoracic Society/European thoracic society [2005] [7].

The COPD severity was categorized according to FEV1% of predicted as the following: mild [FEV1 ≥ 80% of predicted], moderate [50% ≤ FEV1 < 80% predicted], severe [30% ≤ FEV1 <50% predicted], and very severe [FEV1 <30% predicted] [1].

Full echocardiography was performed for all patients by [Vivid S5 N system, USA] and a transducer array of 2-4 MHz, according to the guidelines of American Society and European Association of Echocardiography [8]. All measurements were registered at end expiration. We used M-mode and two-dimensional techniques to assess the left ventricular ejection fraction. In addition, the dimension techniques in short-axis and long-axis left parasternal views were used. The peak velocity of early diastolic flow [E], peak velocity of atrial contraction [A], and their ratio [E/A], were measured to assess the diastolic function of the left ventricle. These measures were done over the mitral valve in apical four chamber view with color flow imaging for standard alignment of pulsed wave Doppler with blood flow. The size of the right ventricle was calculated by measurement of right internal mid-cavity dimensions in apical four-chamber view. The tricuspid annular plane systolic excursion [TAPSE] was registered in the apical four-chamber view to assess right ventricle [RV] systolic function. We used color flow Doppler technique to identify tricuspid regurge 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 [mmHg] = RVSP = trans-tricuspid pressure gradient + 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].

The study protocol was revised and accepted by the local research ethics committee of Faculty of Medicine Al-Azhar University [Assiut Branch].

Statistical analysis: All statistical tests and measurements were completed using the SPSS [The statistical package for social sciences], version 16 [SPSS Inc.., USA]. The arithmetic mean, standard deviation or their equivalents were calculated for numerical data. Otherwise, the frequency and percentages were used to express the categorical variables. Differences between means were analyzed by parametric tests [the independent sample *t*-test, and one-way analysis of variance [ANOVA] test]. However, the differences between categorical variables were analyzed using the Chi square-test, or its equivalent. For all tests, the *P*-value less than or equal to 0.05 was regarded as statistically significant.

RESULTS

Our study included 52 [86.66%] males and 8 [13.33%] females, with mean age of 58.4±7.7 years. Their age ranged from 40 to 79 years old. Eight patients [13.34%] had mild COPD, 18 [30.0%] had moderate disease, 27 [45.0%] had severe disease and 7 [11.66%] had very severe disease. The echocardiographic examination of the RV revealed RV dilatation in 10 subjects [16.7%]. TR was found in 71.6%, with variable grades from mild to severe [11 had mild, 20 had moderate, and 12 had severe TR], with positive correlation between grades of obstruction and TR. TAPSE was normal in all patients. Cases with severe/very severe disease [n=34] had significantly increase of right ventricular size [mm] than those with mild/moderate [n=26] [31.9±6.7 vs 28.35±6.8, $p < 0.05$].

In addition, patients with severe/very severe diseases had significantly higher number of severe and moderate TR than those with mild/moderate disease [Table 1]. Pulmonary hypertension was found in 56% 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 [25%] who developed Pulmonary hypertension had mild degree of Pulmonary hypertension [35–49 mmHg]. frequencies of Pulmonary hypertension with severity of COPD of our cases are shown in Tables [2 and 3]. Cor pulmonale was found in 20% of patients and the majority of patients presented to the hospital by cor pulmonale were in very severe stage of COPD was [3 patients, 42.9%], No co-relation exists between frequency of cor pulmonale and severity of COPD. frequencies of cor pulmonale with severity of COPD of our cases are shown in Table [4].

Echocardiographic examination of left ventricular systolic functions revealed mild to moderate left ventricular dimensions dilatation in 35% of patients, whereas mild impairment of systolic function of left ventricle was seen in 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 25% of the patients. Motion wall abnormalities were not found in the patients of this study. 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 5].

Table [1]: **Comparison between grades of obstruction regarding tricuspid regurge.**

Tricuspid regurge	Mild/ Moderate[n=26]		Severe/Very severe[n=34]		P. value
	No.	%	No.	%	
None	3	11.6	2	5.9	0.007*
Minimal	6	15.4	6	17.7	
Mild	8	30.8	3	8.9	
Moderate	9	34.7	11	32.4	
Severe	0	0	12	35.5	

Table [2]: Distribution of patients by Pulmonary Arterial Hypertension.

PAH category	No.	%
Normal [PASP≤25]	26	43.33
Mild [PASP 25-49]	16	26.66
Moderate [PASP 50-69]	14	23.33
Severe [PASP ≥70]	4	6.67

Table [3]: Frequency of Pulmonary hypertension with severity of COPD.

Severity of COPD	No.	%
Mild [8]	2	25
Moderate [18]	10	55.6
Severe [27]	16	59.3
Very severe [7]	6	85.71

Tab [4]: Frequency of cor pulmonale with severity of COPD.

Severity of COPD	No.	%
Mild [8]	3	37.5
Moderate [18]	2	11.11
Severe [27]	4	14.8
Very severe [7]	3	42.9

Table [5]: Correlation between respiratory function and echocardiography findings.

		FEV1/FVC		FEV1 %	
		r	p	r	p
Age		-.993-**	<0.001	-.832-**	<0.001
LVF		-0.104	0.430	-0.083	0.531
LVDd		0.171	0.192	0.163	0.212
LVDs		0.234	0.073	0.290	0.125
RVSP		-0.904-**	<0.001	-0.739-**	<0.001
TAPSE		0.063	0.632	0.032	0.806
E/A ratio		0.135	0.303	0.079	0.550

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. [a]Pearson's correlation. [b]Partial correlation [controlled for age]. *Significant.

DISCUSSION

Cardiovascular disease [CVD] is common among patients with COPD. Cigarette smoking is a risk factor for the development of COPD and CVD, but does not fully explain this association. Different explanations have been suggested, including systemic inflammation, vascular dysfunction and lung hyperinflation [11].

COPD is considered a worldwide cause of chronic morbidity and mortality [2]. Patients with COPD have a high risk of cardiovascular disease, and it can be a cause of their death [12, 13].

COPD can affect pulmonary blood vessels, right side of the heart, and may affect left side of the heart [14, 15].

The aim of this study was to evaluate cardiac dysfunction by echocardiography in chronic obstructive pulmonary disease patient.

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

The current study showed that RV dilatation was found in early stages of COPD in 16.7% of patients. Frequency of right ventricle enlargement in ECHO in mild to moderate, severe to very severe COPD was 26.9%, and 8.8%, respectively. This agreed with Hilde *et al.* [16].

Moreover, there was a positive correlation between severity of COPD and RV size. This is similar to the studies conducted by Hilde *et al.* [15], Jatav *et al.* [17], Jain *et al.* [18], and Khatri *et al.* [19].

In this study, TR was present in 43 patients 71.6% of the patients with variable grades from mild to severe. There was a positive correlation between grades of obstruction and tricuspid regurge. Similar findings were observed in study of Jain *et al.* [18], Maula *et al.* [20], Kaur *et al.* [21] and Tiwari *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 [15, 23, 24].

In this study showed that the presence of PH, that is, pulmonary artery systolic pressure more than 35 mmHg, was 56%. PH appeared more in severe and very severe grades of the disease than in mild/moderate disease. These results agreed with Jatav *et al.* [17], Elwahsh *et al.* [25], Kaur *et al.* [21], Khatri *et al.* [19] 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. It also agreed with Nowak *et al.* [26] but disagree with Hirachan *et al.* [27].

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.* [28] who found that the magnitude of PH was mild in most cases and only 3% of patients had severe PH.

In this study, TAPSE was used as easily obtainable measure of RV systolic function, and it was normal 58 [96%] patients, which are in contrary to Hilde *et al.* [16] who included some patients with COPD with very severe degree of obstruction with respiratory failure and TAPSE was lower in them than controls.

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 26.7% of patients, whereas mild to moderate left ventricular dimensions dilated in 30%. True prevalence of LVSD is unknown. It varies widely, from 0 to 25%, as reported by Portillo *et al.* [29], 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.* [29] 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 this 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*. [29]. 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 26.7%. This was in contrary to Huang *et al*. [30] who showed a higher frequency of LVDD in patients with COPD [65.6%] and Caram *et al*. [31] who reported high frequency up to 88%. Another study by López-Sánchez *et al*. [32] focused on severe COPD outpatients and showed a highest prevalence of LVDD [90%] [30, 31].

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*. [30].

In this study, there was some limitation such as using two-dimensional Doppler echocardiogram with colour 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 inpatients with COPD but it is not related to the disease severity. Abnormal right heart changes could be expected. Pulmonary blood vessels, right side of the heart are affected by COPD and may affect left side of the heart. Screening of pulmonary blood vessels by echocardiography can help in diagnosis of pulmonary hypertension [PH] as PH is a frequent complication of COPD. Prevalence of PH has a linear relationship with severity of COPD.

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3/2022

International Journal of Medical Arts

https://ijma.journals.ekb.eg/
Print ISSN: 2636-4174
Online ISSN: 2682-3780