

Correlation between ventricular function as assessed by echocardiography and six-minute walk test as a surrogate of functional capacity in patients with chronic obstructive pulmonary disease

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Background Exercise intolerance is common in patients with chronic obstructive pulmonary disease (COPD), which has multiple mechanisms underlying its progression. Ventricular dysfunction may play a role in the development of exercise incapacity in patients with COPD.

Aim To investigate the possible contribution of left ventricular (LV) and right ventricular (RV) dysfunction (either systolic or diastolic) in development of exercise intolerance in patients with COPD.

Patients and methods A total of 60 patients with diagnosis of COPD were categorized according to GOLD spirometric stage into two groups (group 1: mild to moderate COPD, and group 2: severe to very severe COPD). Both groups were evaluated by spirometry, ECG, chest radiography, routine laboratory investigation, 6-min walk test, and echocardiography including tissue Doppler imaging.

Results The average age in the whole study group was 56.63 ±10.33 years. Male patients in the study were 46 (76.7%) and female patients were 14 (23.3%). Mean maximum walk distance among the whole group was 342.75±54.85 m. There was a significant correlation between 6-min walk distance and transtricuspid E velocity, tricuspid E/A, and transtricuspid deceleration time ($P=0.011$, 0.015, and 0.021, respectively). There was no significant correlation between 6-min walk

distance and parameters of LV diastolic dysfunction. Prevalence of ventricular dysfunction was as follow: LV systolic dysfunction 3.3%, LV diastolic dysfunction 30%, RV systolic dysfunction 21%, and RV diastolic dysfunction 46%.

Conclusion RV diastolic dysfunction may be a contributing factor in the progression of exercise intolerance in COPD. Although LV diastolic dysfunction may not be associated with exercise intolerance, it is still prevalent in COPD and must be assessed and managed through the course of the disease and especially during exacerbation.

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Keywords: 6-min walk test, chronic obstructive pulmonary disease, echocardiography, exercise intolerance, ventricular dysfunction

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Introduction

Chronic obstructive pulmonary disease (COPD) is on its way to be the third most common killer disease worldwide by 2020 [1,2]. Although being of primary pulmonary origin, it has a unique physiological and pathophysiological characteristics that may cause extrapulmonary effects and comorbidities [3–5]. Comorbidities are associated with high mortality, reduced compliance to medications, and diminished quality of life [6]. Cardiovascular comorbidities are among the most frequently seen comorbidities associated with COPD [4,7]. Many studies have demonstrated a strong association between heart failure and COPD [8–10].

Exercise intolerance is common in patients with COPD, which has multiple mechanisms underlying its progression. Increased ventilatory demand, associated with altered dynamic mechanics, abnormal gas exchange, airway limitation, and peripheral muscle dysfunction, is among the intrinsic

pulmonary mechanisms that are alleged for exercise incapacity seen in such patients [11–15]. There is increasing evidence that ventricular dysfunction may play a role in development of exercise intolerance in patients with COPD.

In the present study, we tried to assess the left ventricular (LV) and right ventricular (RV) function either systolic or diastolic in patients with COPD. We tried to correlate echocardiographic parameters of ventricular function with 6-min walk test as a surrogate for exercise capacity to reveal any contribution of ventricular function on exercise intolerance found in patients with COPD.

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Patients and methods

The protocol of the study was approved by Research Ethics Committee REC, Ain Shams University (FMASU MD 196/2016). The study included 60 patients. Inclusion criteria entailed sure diagnosis of COPD (presence of risk factors, clinical symptoms and signs, radiology, and spirometry) among patients who were admitted to inpatient and outpatient clinic in Kafr El-Sheikh Chest Hospital in the period from December 2016 to July 2018. Exclusion criteria were the presence of severe liver or kidney disease, presence of recent or old ischemic heart disease or other valvular heart disease, severe systemic hypertension, pulmonary disease other than COPD, acute venous thromboembolism, hemoglobin less than 10 g/dl, patients who cannot perform spirometry or 6-min walk test, and patients with acute exacerbation of COPD. After taking a written and informed consent from all patients participating in the study, patients were categorized according to GOLD spirometric criteria into group 1 (mild to moderate COPD, forced expiratory volume in 1 s (FEV1)/forced vital capacity <70%, and FEV1>50%) and group 2 (severe to very severe COPD, FEV1/forced vital capacity <70%, and FEV1<50%). Routine laboratory investigations to exclude severe liver or kidney diseases were performed. Chest radiography to ensure hyperinflation and rule out any other chest diseases and ECG to exclude ischemic changes or arrhythmias were done. Six-min walk test was performed according to ATS guidelines for all participants [16]. Patients were instructed to walk through a corridor of 30-m length as fast as they can for 6 min. They were encouraged by simple words throughout the test and were instructed to stop immediately if they feel they cannot complete the test or if any complications occurred. The outcome of the test was recorded as the maximum distance the patient walked, the basal and post-test heart rate, the basal and post-test oxygen saturation, and complication during the test (if occurred). Echocardiography was done for all patients in the cardiology department, EL-Obour Insurance Hospital, using General Electric (GE) machine, VIVID S5, with a transducer (probe), 3S-RS 1.5–3.6 MHz. Images were acquired according to the latest guidelines [17,18] (Fig. 1) and revised by two cardiologists in the department.

Linear LV dimension was taken from parasternal long-axis PLAX at the end of diastole, and ejection fraction (by Teicholtz method) and fractional shortening were derived. Transmitral flow was assessed using E, A, E/A, and deceleration time. Then tissue Doppler imaging (TDI) modality was used to measure e', and E/e' was calculated.

RV linear dimensions were obtained in apical four-chamber view. Tricuspid annular plane excursion (TAPSE) was measured by 2D modality, and then transtricuspid flow was assessed similar to transmitral flow using E, A, E/A, and deceleration time. TDI was used to measure myocardial peak tricuspid annular velocity (S') and E', and then E/E' was calculated.

LV systolic dysfunction was present when EF is less than 50%. LV diastolic dysfunction was present when two of the following criteria are present [19]: (a) lateral e' velocity less than 10 m/s (0.10 m/s), (b) E/e' more than 14, and (c) tricuspid regurgitant velocity more than 2.8 m/s.

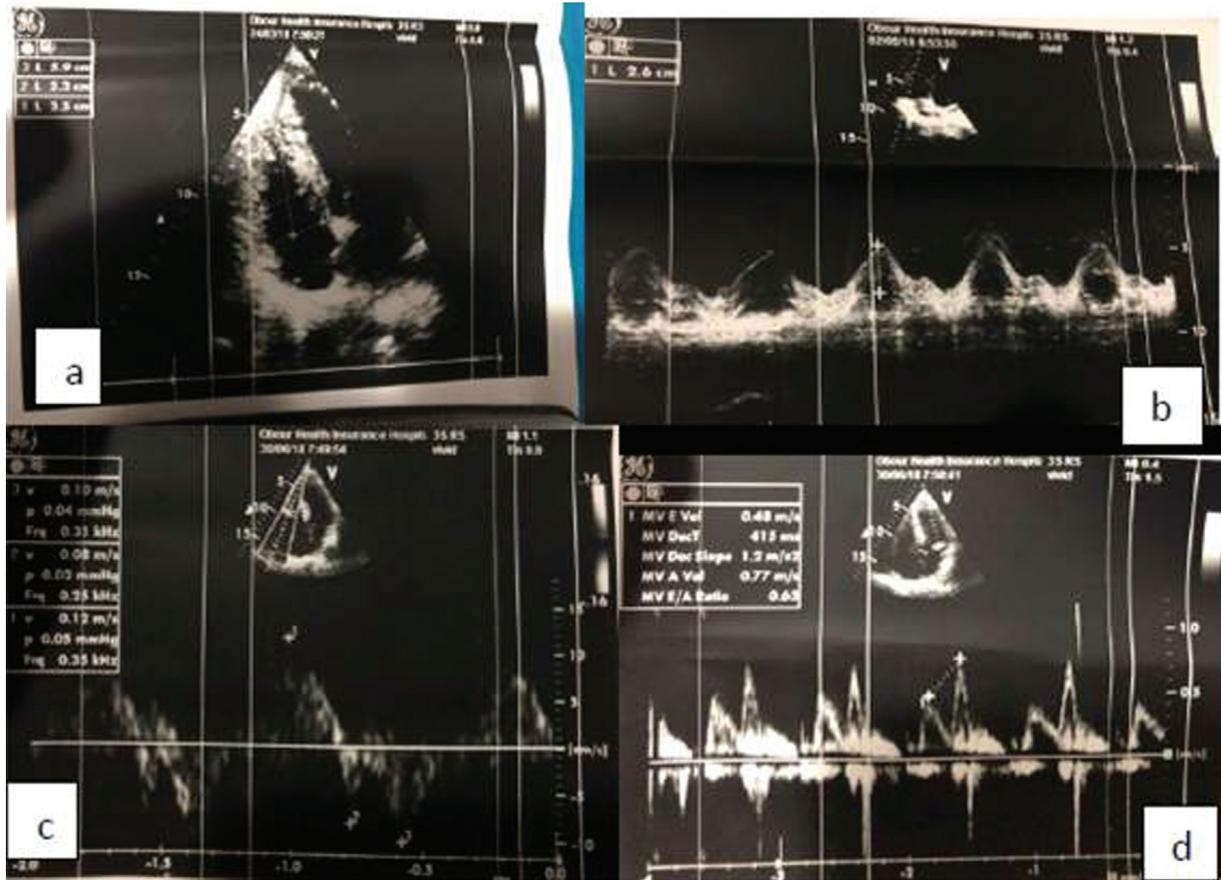
RV systolic dysfunction was present when TAPSE less than 1.6 cm or S' less than 10 cm/s (0.10 m/s). RV diastolic dysfunction was present when one of the following was present: (a) E/A<0.8, (b) E/A from 0.8 to 2.1 and E/E' >6, and (c) E/A more than 2.1 and deceleration time less than 120 ms.

The collected data were revised, coded, tabulated, and introduced to a PC using Statistical package for Social Science (SPSS 25; IBM SPSS version 25, Chicago, Illinois, USA). Data were presented, and suitable analysis was done according to the type of data obtained for each parameter. Student *t* test and Mann–Whitney test (*U* test) were used to assess the statistical significance of the difference of parametric and nonparametric variables (respectively) between two study groups. χ^2 test and Fisher's exact test were used to examine the relationship between two qualitative variables according to their number. Correlation analysis (using Pearson's method) was used to assess the strength of association between two quantitative variables.

Results

Table 1 summarizes patients data, comorbidities, laboratory investigations, arterial blood gases, spirometry, and 6-min walk test. Male patients in the study were 46 (76.7%) and female patients were 14 (23.3%). Both groups included 23 (76.67%) males and seven (23.33%) females. Dyspnea was the most frequent complaint. Most patients were current smokers (46.7%) or ex-smokers (30.0%). Systemic arterial hypertension was the most common comorbidity (21%). One patient had hypothyroidism and liver cirrhosis, and another one had hypertension and HCV. Normal sinus rhythm with no ischemia was the most common finding in ECG, and all patients showed signs of hyperinflated chest on

Figure 1



(a) Linear dimensions of right ventricle: basal diameter, mid cavity, and longitudinal. (b) TAPSE by applying M-mode at the lateral free wall of RV. (c) Myocardium velocities by TDI at the lateral tricuspid annulus: 1→ S', 2→ E'. (d) Transmitral flow parameters: E, A, and E/A. RV, right ventricular; TAPSE, tricuspid annular plane excursion; TDI, tissue Doppler imaging.

plain chest radiography. Mean±SD maximum walk distance among the whole group was 342.75 ±54.85 m, mean±SD maximum walk distance was 373.33±41.86 m in group A and 312.17±49.32 m in group B. Mean LV and RV echocardiographic parameters representative of both systolic and diastolic functions are summarized in Table 2.

Correlation between 6-min walk test and ventricular function

There was a significant positive correlation between 6-min walk distance and ejection fraction of the LV among the whole study group. There was no significant correlation between 6-min walk distance and other parameters of LV diastolic dysfunction. Regarding the RV, there was a significant correlation between 6-min walk distance and transtricuspid E velocity (Fig. 2), tricuspid E/A (Fig. 3), and transtricuspid deceleration time (Fig. 4) ($P=0.011$, 0.015 , and 0.021 , respectively). These are parameters of RV diastolic dysfunction. There was a significant correlation between 6-min walk distance and TAPSE (parameter indicative of systolic function)

in mild to moderate COPD. In patients with severe to very severe COPD, there was a significant correlation between 6-min walk distance and RV E/A (Fig. 5).

Prevalence of ventricular systolic and diastolic dysfunction in patients with chronic obstructive pulmonary disease

LV systolic dysfunction was present in 3.3% of study population (Table 3). There was no significant difference between both groups. LV diastolic dysfunction occurred in 18 (30%) patients. Among these 18 patients, grade 1 diastolic dysfunction (impaired relaxation) was present in 15 (25%) patients and grade 2 diastolic dysfunction (pseudonormal filling) was present in three (5%) patients.

RV systolic dysfunction occurred in 13 (21.7%) patients. There was no significant difference between both groups. RV diastolic dysfunction occurred in 28 (46.7%) patients. Among these 28 patients, grade 1 diastolic dysfunction (impaired relaxation) was present in 14 (23.3%) patients, grade 2 diastolic dysfunction (pseudonormal filling) was present in 11 (18.3%) patients and grade 3 diastolic dysfunction (restrictive filling) was present in three

Table 1 Patients data, laboratory investigations, arterial blood gas, pulmonary function test, and 6-min walk test results

	All patients	Group 1	Group 2	P value	Significance
Age	56.63±10.33	51.63±11.16	61.63±6.38	<0.001	S
Male	46 (76.7)	23 (76.67)	23 (76.67)		
Female	14 (23.3)	7 (23.33)	7 (23.33)		
Height (cm)	166.82±8.23	167.8±7.34	165.83±9.06	0.359	NS
Weight (kg)	71.55±9.15	71.63±8.1	71.47±10.22	0.944	NS
No smoke	14 (23.3)	7 (23.33)	7 (23.33)		
Smoking	28 (46.7)	15 (50)	13 (43.33)		
Ex-smoking	18 (30.0)	8 (26.67)	10 (33.33)		
No comorbidities	41 (68.3)	23 (76.67)	18 (60)		
HTN	13 (21.6)	4 (13.3)	9 (30)		
DM	2 (3.3)	1 (3.33)	1 (3.33)		
CVS	1 (1.7)	1 (3.33)	0		
Old TB	1 (1.7)	0	1 (3.33)		
Hypothyroidism	1 (1.7)	0	1 (3.33)		
HCV (treated)	1 (1.7)	1 (3.33)	0		
Liver cirrhosis	2 (3.3)	2 (6.6)	0		
Systolic BP	119.17±12.39	116.67±12.41	121.67±12.06	0.119	NS
Diastolic BP	78.25±7.91	77.5±7.51	79±8.35	0.467	NS
Basal heart rate	83.08±9.69	81.27±10.63	84.9±8.44	0.148	NS
CBC (Hb) (g/dl)	13.10±1.37	13.29±1.42	12.91±1.31	0.286	NS
CBC (TLC ×10 ³)	8.51±3.51	8.41±3.79	8.61±3.27	0.825	NS
pH	7.40±0.04	7.4±0.04	7.39±0.05	0.335	NS
PO ₂ (on room air)	65.0±7.0	68.8±6.5	60.37±4.93	<0.001	S
PCO ₂	43.0±6.0	41.47±5.74	45.33±6.04	0.014	S
FEV1 (l)	1.41±0.58	1.85±0.39	0.97±0.33	<0.001	S
FEV1 of predicted	46.33±16.10%	60.27±6.55%	32.4±9.09%	<0.001	S
FVC (l)	2.35±0.93	3.07±0.67	1.63±0.49	<0.001	S
FEV1/FVC	60.70±6.67%	60.53±7.09%	60.87±6.33%	0.848	NS
Maximum walk distance (m)	342.75±54.85	373.33±41.86	312.17±49.32	<0.001	S
Basal SPO ₂	92.33±2.52%	93.2±2.38%	91.47±2.39%	0.007	S
Post-test SPO ₂	90.40±3.22%	91.87±2.75%	88.93±3.02%	<0.001	S
Post-test heart rate	89.62±12.58	85.13±9	94.1±14.13	0.005	S

The mean and SD of demographic data, comorbidities, signs and symptoms, laboratory investigations, and outcome of 6-min walk test among the whole study group and comparison between both study groups. BP, blood pressure; CBC, complete blood count; DM, diabetes mellitus; FEV1, forced expiratory volume in 1 s; FVC, forced vital capacity; Hb, hemoglobin; HTN, hypertension; S, significance; TLC, total leukocyte count.

(5%) patients. There was a significant difference between both groups, with an increased prevalence of diastolic dysfunction among severe and very severe COPD. Prevalence of RV diastolic dysfunction in this group reached 76%, which supports the accumulating evidence of the importance of RV pathology in the course of the disease.

Discussion

The main findings in the present study are the high prevalence of RV and LV diastolic dysfunction in patients with COPD, and the presence of significant correlation between RV diastolic dysfunction and 6-min walk test, implying a contribution of RV diastolic dysfunction on exercise incapacity.

In the present study, we found no significant correlation between 6-min walk distance and other parameters of

LV diastolic dysfunction. In contrast with our study, López-Sánchez *et al.* [20] found a significant correlation between decreased 6-min walk distance and E/A, indicating contribution of LV diastolic dysfunction in patients' exercise intolerance. One of the limitations of their study is the exclusion of mild to moderate COPD and very severe COPD. They only included patients with severe COPD, which may explain this difference in results. Fenster *et al.* [21] did not find this association between LV diastolic dysfunction and 6-min walk distance reported by López-Sánchez *et al.*. Another study by Schoos *et al.* [22] did not find a correlation between LV diastolic dysfunction and 6-min walk distance. Another recent study by Muller *et al.* [23] compared patients with COPD having LV diastolic dysfunction with patients having no diastolic dysfunction using cardiopulmonary exercise test. They found no association between LV diastolic dysfunction and worsening of exercise tolerance.

Table 2 Echocardiographic parameters of left and right systolic and diastolic functions

	All patients	Group 1	Group 2	P value	Significance
Left ventricle					
LVEDD (cm)	4.73±0.85	4.71±0.8	4.76±0.91	0.822	NS
LVESD (cm)	3.19±0.66	3.15±0.52	3.23±0.78	0.641	NS
IVS (cm)	1.21±0.21	1.17±0.18	1.25±0.23	0.14	NS
PW (cm)	1.28±0.28	1.22±0.28	1.34±0.28	0.103	NS
EF	60.75±7.45%	61.3±6.23%	60.2±8.56%	0.572	NS
E (m/s)	0.58±0.14	0.59±0.15	0.57±0.13	0.465	NS
A (m/s)	0.63±0.17	0.62±0.17	0.65±0.18	0.469	NS
E/A	0.97±0.30	1.0±0.26	0.95±0.34	0.529	NS
E' (m/s)	0.10±0.03	0.11±0.04	0.09±0.02	0.046	S
E/e'	6.30±2.22	6.07±2.46	6.54±1.97	0.411	NS
FS	33.10±5.69%	33.43±4.84	32.77±6.5	0.654	NS
Deceleration time (ms)	218.53±59.96	234.07±56.12	203±60.55	0.044	S
Right ventricle					
RV basal diameter (cm)	3.60±0.47	3.6±0.45	3.59±0.5	0.914	NS
RV mid diameter (cm)	2.81±0.47	2.84±0.48	2.78±0.48	0.648	NS
RV long. diameter (cm)	6.46±0.88	6.5±0.74	6.42±1.01	0.707	NS
TAPSE (cm)	2.06±0.35	2.1±0.34	2.03±0.36	0.422	NS
S' (peak velocity)					
Lat. annulus (m/s)	0.14±0.06	0.13±0.03	0.15±0.09	0.291	NS
RV E (m/s)	0.53±0.11	0.55±0.08	0.51±0.13	0.245	NS
RV A (m/s)	0.55±0.19	0.52±0.11	0.58±0.25	0.246	NS
RV E/A	1.07±0.35	1.09±0.26	1.04±0.43	0.589	NS
E/E'	5.36±1.91	5.21±1.52	5.52±2.25	0.532	NS
RV decel. time (ms)	200.55±45.72	211.6±39.12	189.5±49.69	0.061	NS
TR reg. velocity (m/s)	1.71±0.88	1.41 (0.99–1.9)	1.66 (1.03–2.57)	0.211 (M)	NS
sPAP by (mmHg)	20.09±16.90	12 (9.09–19.44)	16.01 (9.24–31.41)	0.22 (M)	NS

Mean echocardiographic parameters in the whole study group and compares between both study groups. EF, ejection fraction; FS, fractional shortening; IVS, interventricular septum (IVS) thickness; Lt vent A, transmitral A wave velocity; Lt vent e', lateral mitral annulus e' wave velocity by tissue Doppler; Lt vent. E, transmitral E wave velocity; LVEDD, left ventricle end diastolic dimension; LVESD, left ventricle end systolic dimension; PW, posterior wall thickness; RV A, transtricuspid A wave velocity; RV E, transtricuspid E wave velocity; S', right ventricle free wall velocity at tricuspid lateral annulus by tissue Doppler imaging; sPAP, estimated pulmonary artery pressure; TAPSE, tricuspid annular plane systolic excursion.

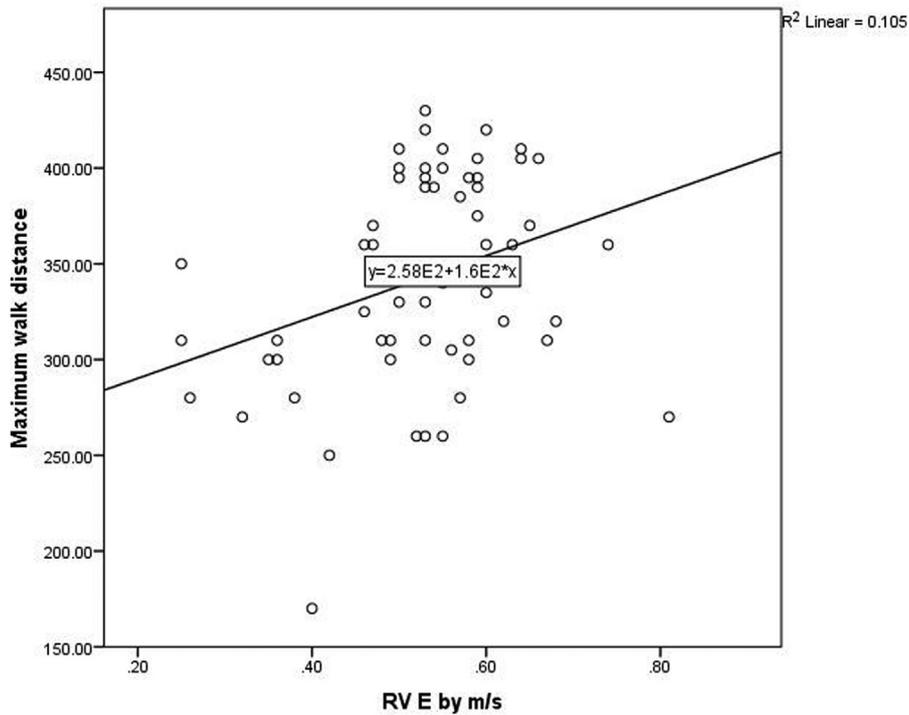
Watz *et al.* [24] estimated Pro-BNP as a marker of myocardial failure and correlated it with 6-min walk test. They concluded that physical activity is associated with LV diastolic dysfunction. Pro-BNP is not specific for LV pathologies and may be increased in RV dysfunction. Patients with LV dysfunction may also have RV dysfunction, which causes the observed exercise intolerance.

Regarding the RV, there was a significant correlation between 6-min walk distance and parameters of RV diastolic dysfunction. This positive correlation among the whole study group suggests a decreased exercise capacity in presence of RV diastolic dysfunction irrespective of COPD spirometric stage, which may suggest that even in mild and moderate airflow limitation, when RV diastolic dysfunction develops, exercise incapacity may evolve.

The role of ventricular dysfunction in progression of exercise intolerance in COPD was not fully determined. Furthermore, the RV was always neglected in traditional

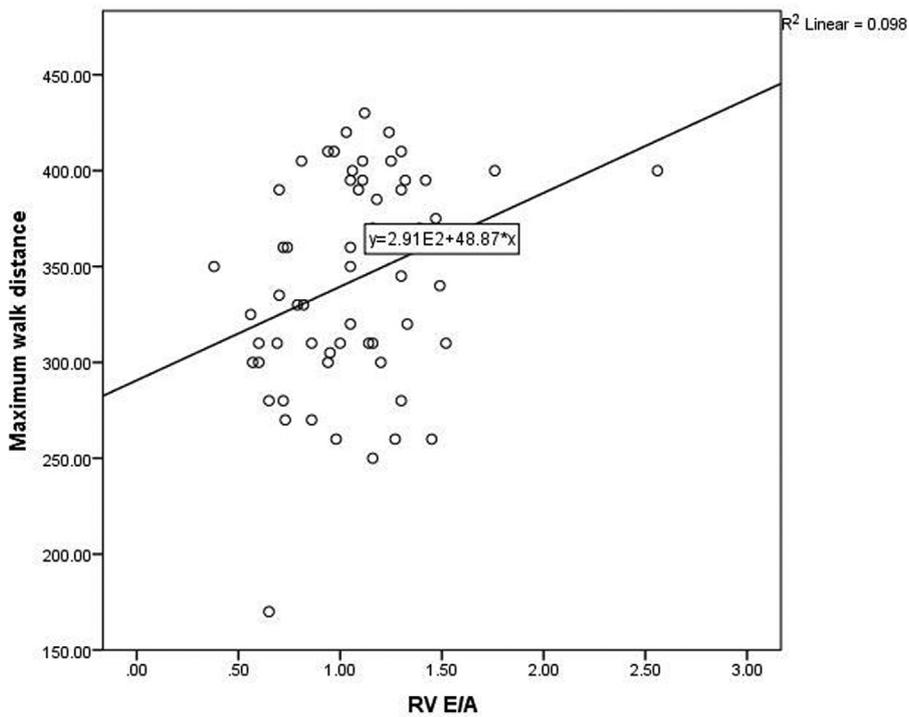
workup and studies to the extent that it was once coined as 'the forgotten chamber' [25]. The present study supports the results of Fenster *et al.* [21], who studied the correlation between 6-min walk test and RV diastolic function. They found a positive significant correlation between 6-min walk distance and RV E/A. They concluded that RV diastolic dysfunction may contribute to exercise intolerance in patients with COPD [21]. They referred the association between RV diastolic dysfunction and decreased exercise tolerance to diminished RV preload and stroke volume, which may be exacerbated during exercise [21]. Although Schoos *et al.* [22] did not find this association between lower 6-min walk distance and RV diastolic dysfunction, they reported a reduction in RV diastolic function parameters. In addition, they excluded mild COPD and very severe COPD, which may affect the overall correlation. Cuttica *et al.* [26], in their study of patients without severely impaired lung function, demonstrated that structural changes of the right heart are associated with a decrement in 6-min walk distance independent of spirometric stage. However,

Figure 2



Correlation between 6-min walk distance and RV transtricuspid E velocity. A lower 6-min walk distance is associated with lower E velocity among the whole study group. RV, right ventricular.

Figure 3

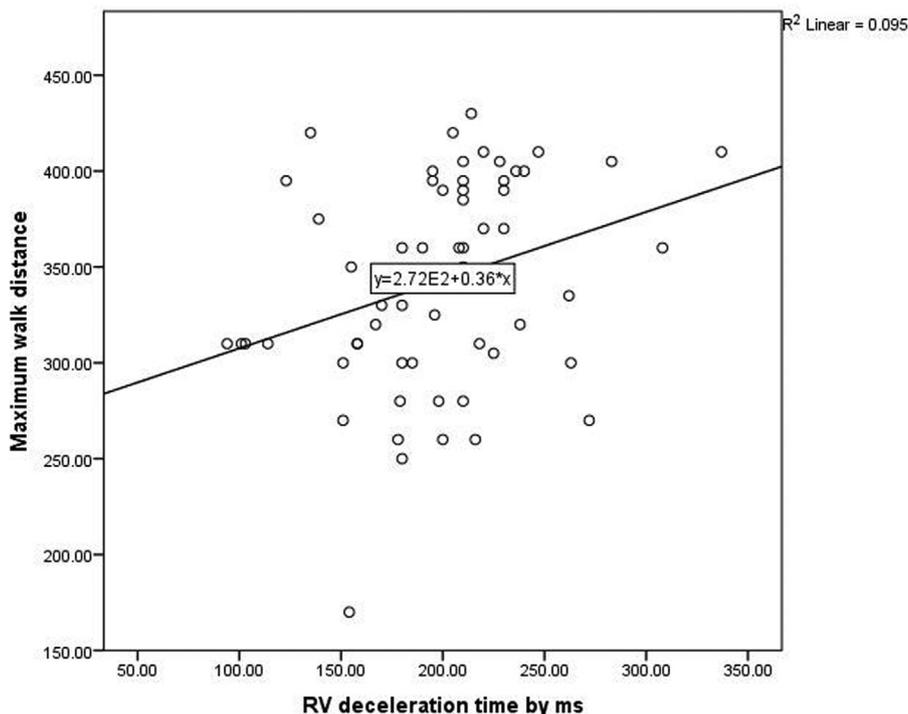


Correlation between 6-min walk distance and right ventricular E/A in the whole study group. A lower 6-min walk distance is associated with lower E/A ratio.

they did not find an association between 6-min walk distance and RV systolic function as assessed by TAPSE or LV systolic or diastolic function [26].

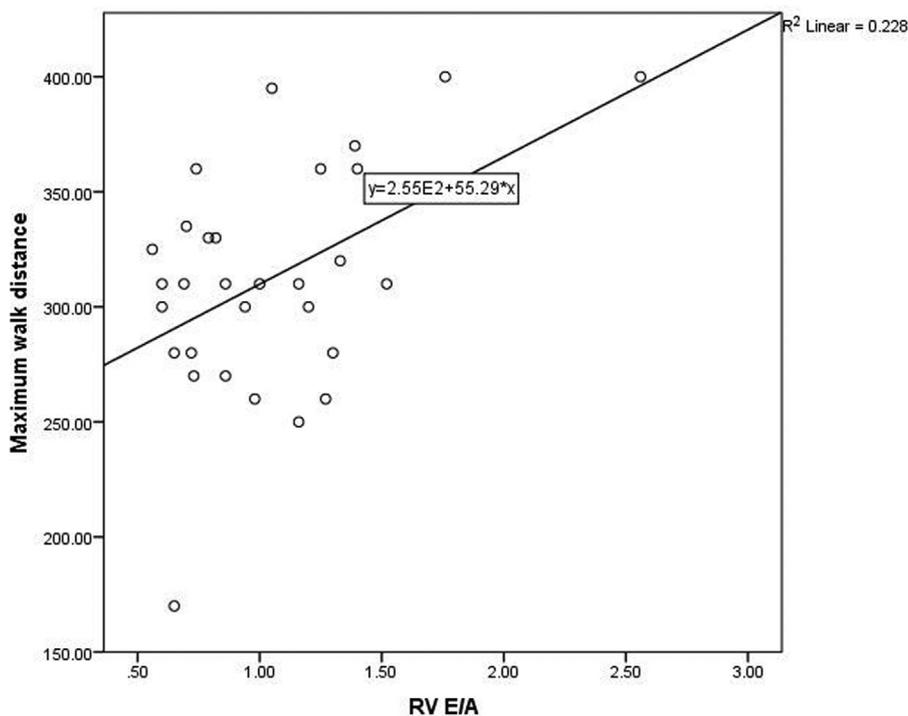
Although our study did not include control group, there is a large body of evidence that LV dysfunction is prevalent in patients with COPD

Figure 4



Correlation between 6-min walk distance and right ventricular deceleration time in the whole study group. A lower 6-min walk distance is associated with lower deceleration time.

Figure 5



Correlation between 6-min walk distance and transtricuspid E/A in group B. A lower 6-min walk distance is correlated with a lower E/A in patients with severe to very severe COPD. COPD, chronic obstructive pulmonary disease.

[20,27–31]. Prevalence of LV diastolic dysfunction varies largely between different studies. Our estimate is relatively close to another study by Gupta *et al.* [27]

who reported a prevalence of 47.5% among their study group which include 40 patients with COPD of different spirometric stages. Another recent study by

Table 3 Prevalence and grades of left and right ventricular dysfunction

	All patients	Group 1	Group 2	P value	Significance
LV systolic dysfunction	2 (3.3)	1 (3.33)	1 (3.33)	1.00 (F)	NS
LV diastolic dysfunction	18 (30.0)	6 (20)	12 (40)	0.091 (C)	NS
Grade 1	15 (25.0)	6 (20)	9 (30)	0.141	NS
Grade 2	3 (5.0)	0	3 (10)		
RV systolic dysfunction	13 (21.0)	4 (13.33)	9 (30)	0.117 (C)	NS
RV diastolic dysfunction:	28 (46.7)	7 (23.33)	21 (70)	<0.001 (C)	S
(a) Grade 1	14 (23.3)	4 (13.33)	10 (33.33)		
(b) Grade 2	11 (18.3)	3 (10)	8 (26.67)	0.002	S
(c) Grade 3	3 (5)	0	3 (10)		

This table represents the prevalence of systolic and diastolic dysfunction of the left and right heart among the whole study group and in both study groups. LV, left ventricular; RV, right ventricular; S, significance.

Jatav *et al.* [28] estimated LV diastolic dysfunction to be 46% in a sample of 100 patients with COPD. This is in contrary to a study performed by Miranda *et al.* [29] who reported a prevalence of LV diastolic dysfunction of 88% among their study group and also observed a significant difference between both groups of study (group 1: mild to moderate COPD and group 2: severe to very severe COPD). López-Sánchez *et al.* [20] found LV diastolic dysfunction in 90% of their group (80% grade 1 and 10% grade 2). Rawy and Fathalla [30] reported a prevalence of 73.3%. However, many authors argue that, Freixa *et al.* reported a prevalence of 12% in COPD patients on their first hospital admissions [31]. But actually Freixa and colleagues found diastolic dysfunction in about 60% of their study sample but were exposed to error in data summarization and reporting.

This difference in the prevalence of diastolic dysfunction may be owing to variability in echocardiographic parameters needed to diagnose and grade diastolic dysfunction. One of the contributions of the present study is the utilization of the most recent algorithm suggested by the American Society of Echocardiography published in 2016 for diagnosis and grading of LV diastolic dysfunction in our patients' diagnosis and grading. Systemic hypertension and cardiac ischemia are the most common causes of diastolic dysfunction. Another contribution of the present study is the exclusion of patients with a prior history of ischemic heart diseases, and patients with severe arterial hypertension who may not be excluded in some other studies [29].

In the present study, RV systolic dysfunction occurred in 13 (21.7%) patients. There was no significant difference between both groups. In the previously mentioned study by Jatav *et al.* [28], RV systolic dysfunction was present in 14% of patients. In the study by Gupta *et al.* [27], RV systolic dysfunction was present in 7.5% of patients. In their study, RV systolic

dysfunction was diagnosed by eyeballing when observing wall motion hypokinesia. Obviously, this method may underestimate the presence of impaired function in many patients. Vizza *et al.* [32] estimated the prevalence of RV systolic dysfunction (defined by RV ejection fraction <45%) in patients with COPD as 59%. An advantage of using TDI to assess RV function is that measurement is independent of geometric assumptions and endocardial border tracing. Another strength of the present study is the incorporation of TDI parameters like peak tricuspid lateral annulus velocity (S') in assessment of RV systolic function evaluation.

Importantly, RV dysfunction either systolic or diastolic was formerly linked to development of pulmonary hypertension. The increased pulmonary vascular resistance with subsequent increase in RV afterload will lead to RV hypertrophy, and then dilation and even RV failure. Recent studies have demonstrated that RV dysfunction may occur even in the absence of pulmonary hypertension. They referred RV changes to other mechanisms such as systemic inflammation, microvascular ischemia, hypoxia, systemic hypertension and obesity [21,33–37]. Hilde *et al.* [38] concluded a similar observation about the presence of RV function changes in absence of pulmonary hypertension in patients with COPD. From a clinical point of view, exercise training is proved to enhance exercise capacity and quality of life in patients with heart failure with preserved ejection fraction [39,40] which is frequently caused by RV dysfunction [41–44] or LV diastolic dysfunction [45]. Owing to the high prevalence of RV systolic and diastolic dysfunction and LV diastolic dysfunction in our patients with COPD, exercise training should be prescribed in patients with COPD having these ventricular abnormalities. Moreover, avoiding tachycardia by correcting hypoxemia and optimizing medication is mandatory to maintain LV filling [46]. It is not clear whether phosphodiesterase inhibitors

(PDE 5) – which is proved to improve RV function [47] – enhance RV function by direct mechanism or by improving RV afterload [21]. So, the role of PDE 5 in RV diastolic dysfunction in patients with COPD should be evaluated. Again, LV diastolic dysfunction and RV dysfunction should be assessed and managed promptly in every COPD exacerbation as they may be the cause of cardiac decompensation responsible for this exacerbation [48].

Limitations

The study was cross-sectional, so firm conclusions about causality cannot be made. Moreover, we did not have a control group, so we used reference values from literature. Performing echocardiography was difficult in patients with COPD because of the limited acoustic window owing to hyperinflation; however, only measurements with a satisfactory image quality have been used for analyses.

In conclusion, RV diastolic dysfunction may be a contributing factor in progression of exercise intolerance in COPD regardless of patients' spirometric stage. Although LV diastolic dysfunction may not be associated with exercise intolerance, it is still prevalent in COPD and must be assessed and managed through the course of the disease and especially during exacerbation.

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Conflicts of interest

There are no conflicts of interest.

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