E Journal of Cardiovascular Medicine
Research Article
51
EJCM 2024;12(2):51-59
DOI: 10.32596/ejcm.galenos.2024.2023-5-9

Markers of Right-Sided Heart Failure as Predictors of Chronic Obstructive Pulmonary Disease

Wissam Sleiman[1*], Youssef Jalloul[2*], Ali Zgheib[2], Antonios Zakharia[2], Maha Makki[3*], Hani Tamim[3,4*], Pierre Bou Khalil[1*], Marwan M. Refaat[2*]

[1]American University of Beirut Medical Center, Department of Internal Medicine, Division of Pulmonary and Critical Care Medicine, Beirut, Lebanon
[2]American University of Beirut Medical Center, Department of Internal Medicine, Division of Cardiology, Beirut, Lebanon
[3]American University of Beirut Medical Center, Clinical Research Institute, Beirut, Lebanon
[4]Alfaisal University College of Medicine, Riyadh, Saudi Arabia

*These authors contributed equally.

Abstract

Objectives: Chronic obstructive pulmonary disease (COPD) is an inflammatory disease with systemic manifestations. Heart failure (HF) is the most critical heart condition associated with COPD. Lung diseases are probably associated with right ventricular (RV) dysfunction, but few studies have investigated this. In this study, we identified whether the prevalence of RV dysfunction among patients with COPD is higher than that among patients without COPD.

Materials and Methods: In this retrospective cross-sectional study, we included active/former smokers over the age of 40 years with pulmonary function testing (PFT) at the American University of Beirut Medical Center from January to December 2014 and echocardiography within 1 year of the PFT. We classified a total of 135 patients into two groups: a COPD group and a non-COPD control group.

Results: COPD was significantly associated with increased odds of increased pulmonary vascular resistance (adjusted odds ratio: 1.99, 95% confidence interval: 1.15-3.46), after adjusting for age, gender, smoking, HF, and diastolic dysfunction. However, COPD was not associated with tricuspid annular plane systolic excursion (p=0.15).

Conclusion: Echocardiographic RV dysfunction is associated with COPD. Future prospective research can help put things into perspective and help differentiate COPD severity and projection.

Keywords: COPD, right ventricular dysfunction, doppler echocardiography, cardiac diseases, pulmonary vascular resistance, pulmonary hypertension

Address for Correspondence: Marwan M. Refaat, American University of Beirut Faculty of Medicine, Department of Biochemistry and Molecular Genetics; American University of Beirut Medical Center, Department of Internal Medicine, Division of Cardiology/Cardiac Electrophysiology, Beirut, Lebanon

Phone: +961-1-350000/+961-1-374374 **e-mail:** mr48@aub.edu.lb **ORCID:** orcid.org/0000-0002-3210-1987

Received: 30.08.2023 **Accepted:** 02.06.2024

Cite this article as: Sleiman W, Jalloul Y, Zgheib A, et al. Markers of Right-Sided Heart Failure as Predictors of Chronic Obstructive Pulmonary Disease. EJCM 2024;12(2):51-59.
DOI: 10.32596/ejcm.galenos.2024.2023-5-9

EJCM ejcvsmed.com E Journal of Cardiovascular Medicine

Introduction

The inflammatory state in chronic obstructive pulmonary disease (COPD) is thought to be systemic, affecting both pulmonary and non-pulmonary organs[1-3]. COPD and cardiovascular disease (CVD) share common risk factors, the most important of which are smoking and advanced age.

One of the first studies to evaluate the relationship between COPD and the incidence of CVD was published in 2005. COPD was found to be a predictor of CVD hospitalization and mortality. COPD was associated with a high incidence of heart failure (HF) complications, with an adjusted relative risk of 3.75 and 3.53 for HF-related hospitalization and mortality respectively[4]. These results were further supported by another study where patients with PE and HF had the highest odds ratio (OR) of having COPD, of 5.46 and 3.84 respectively[5].

Few studies have assessed the specific association between right ventricular (RV) dysfunction and COPD. Furthermore, smoking and advanced age are common risk factors for both conditions, and most studies determining the frequency of RV or left ventricular dysfunction among patients with COPD did not control for these confounding risk factors[6]. In 2015, Caminiti et al.[7] studied the impact of RV dysfunction on the functionality of patients with COPD. RV function was assessed by measuring the tricuspid annular plane systolic excursion (TAPSE) via echocardiography. The functionality of the subjects was determined by assessing their exercise tolerance using the 6MWT. The study identified that RV dysfunction defined by TAPSE ≤16 mm (0.016 m) was an indicator of decreased 6MWT distance at baseline and 6MWT distance change in COPD patients undergoing pulmonary rehabilitation[7]. In Lebanon, no formal study has assessed the relationship between RV dysfunction and COPD. In this study, we evaluated the prevalence of RV dysfunction (as measured by echocardiography) among patients with COPD and compared it with a control group of non-COPD patients. We then used the markers of RV dysfunction to predict COPD.

Materials and Methods

Patient Selection

We designed this study as a retrospective cross-sectional study. We reviewed the medical charts of patients who underwent PFT at the American University of Beirut Medical Center (AUBMC) between January and December 2014. We included patients over the age of 40 years who were either active or former smokers (documented on the PFT reports) and who had a documented echocardiography performed at the same institution within 1 year of the time the PFT was performed. We excluded patients under the age of 40 years and non-smokers from this study. We did this to magnify any possible association. We also excluded patients who lacked evidence of echocardiography or PFT at AUBMC. The study group included subjects with spirometry-verified COPD. We included non-COPD patients who were also smokers (referred to as "Non-COPD smokers") as a control group. We further categorized the COPD group according to severity as defined by the Global Initiative for Chronic Obstructive Lung Disease (GOLD) 2011 classification based on measured post-bronchodilator forced expiratory volume in 1st second (FEV1) into mild (FEV1≥80%), moderate (50%≤FEV1<80%), severe (30%≤FEV1<50%), and very severe COPD (FEV1<30%).

Transthoracic Echocardiography

We extracted and analyzed the data after the approval of the Institutional Review Board (IRB) of American University of Beirut (approval no.: BIO-2018-0119, date: 11.07.2018). The need for patients' informed consent was expedited by the IRB. The extractors of the PFT data and the echocardiographic data were blinded to each's results. A cardiologist extracted information relevant to the right heart's function on the basis of saved echocardiograms. The cardiologist reviewed the echocardiogram images and extracted the required information. Although it is well known that COPD patients have poorer acoustic windows than non-COPD patients, the technical quality of the cardiac sonographers at the American University of Beirut

and the use of high-resolution echocardiography machines (GE E9, GE E95, Philips IE33, Philips Epic) yielded a good image quality to interpret and access all cardiac parameters. All echocardiographic parameters were repeated twice by a highly qualified cardiac sonographer and a physician, and in case of high variability, a third reading was performed to ensure accurate assessment.

Outcome

Our primary outcome was to measure the association between COPD and TAPSE and to study whether TAPSE can predict COPD. Based on previous data provided by Gokdeniz et al.[8], Kalaycioglu et al.[9], and Geyik et al.[10], we estimated our sample size based on a mean TAPSE difference between the COPD and non-COPD groups of 2 mm (0.002 m). We also knew from these studies that the standard deviation (σ) is around 4 mm (0.004 m). With 80% power and an alpha of 5%, we estimate that we need a total of around 126 patients to reach statistical significance.

Measurement Cut-offs

We classified 135 patients into a COPD group and a non-COPD group. Baseline demographic data, including gender and age, were documented in addition to smoking status, being an active or former smoker, and the number of pack years involved. We defined the severity of COPD according to the PFT results extracted from the patient's medical records. We documented the presence or absence of RV dysfunction according to the echocardiographic findings of the patients. They were also obtained from the medical records. We assessed RV dysfunction using the following parameters: TAPSE (mm) [abnormal<17 mm (0.017 m)], systolic pulsed Doppler S' wave at the tricuspid annulus (cm/s) [abnormal <9.5 cm/s (0.095 m/s)], the index of myocardial performance (as measured by pulsed Doppler) (abnormal>0.43), fractional area change (FAC-%) (abnormal<35%), and the RV basal/mid cavity/longitudinal diameters (cm) [abnormal>4.2 cm (0.042 m), >3.5 cm (0.035 m), and >8.6 cm (0.086 m) respectively]. We also looked at the RV outflow tract parasternal long axis and short axis (RVOT PLAX/PSAX) proximal diameters (cm) [abnormal>3.3 cm (0.033 m) and >3.5 cm (0.035 m)], the RVOT PSAX distal diameter (cm) [abnormal>2.7 cm (0.027 m)], and the pulmonary vascular resistance (PVR) on echocardiography as estimated from the tricuspid regurgitation velocity (TRV) and velocity time integral (VTI) of RVOT [in Wood units (WU)] [abnormal>1.60 WU (12.80 MPa.s/m^3)][11]. We calculated the PVR based on the following formula 10*[TRV (m/s)]/[RVOT VTI (cm)]+0.16[12]. The RV strain was not evaluated because it was not a part of the echocardiographic images protocol at our institution and because of the lack of experience in accurate assessment. We set our secondary outcome to measure the association between COPD and other markers of RV dysfunction as measured by the cardiac markers listed above. Next, we wanted to measure whether the markers of RV dysfunction could predict COPD using a logistic regression model.

Statistical Analysis

Statistical analysis involved the application of the Pearson's chi-square test to examine the relationships between variables. In addition, multivariate logistic regression was employed to control for potential confounding factors such as age, gender, smoking, and systolic and diastolic HF. The RV failure parameters were analyzed as continuous variables (scale) and categorical variables (nominal). A p-value of 0.05 was predetermined as the threshold for statistical significance. We performed all statistical analyses using the Statistical Package for Social Sciences version 23 for Windows (SPSS, Chicago, Illinois). This study did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Results

We reviewed all reports of PFTs performed at AUBMC between January and December 2014. Out of 1416 patients, only 135 patients met the inclusion criteria: 77 patients in the smoking non-COPD group and 58 patients in the COPD group (Figure 1). A summary of the characteristics of these patients is presented in Table 1. In both groups,

the percentage of males was higher than that of females, but no statistically significant difference was present regarding gender (Figure 2). However, the 2 groups were different regarding both their history of smoking and their age, with the COPD group having a significant association with a prolonged smoking history and being older.

Table 1. Demographics, PFTs, and Echocardiograms of recruited patients

		Normal (n=77)	COPD* (n=58)	p-value
Age	Mean (SD)	62.77 (12.15)	71.21 (9.22)	<0.001
	<70 years	55 (71.4%)	23 (39.7%)	<0.001
	≥70 years	22 (28.6%)	35 (60.3%)	
Gender	Male	52 (67.5%)	45 (77.6%)	0.20
	Female	25 (32.5%)	13 (22.4%)	
Smoking	Mean (SD)	41.48 (30.72)	54.98 (34.49)	0.028
	≤50 pack years	40 (65.6%)	33 (60.0%)	0.54
	>50 pack years	21 (34.4%)	22 (40.0%)	
FEV1**%	Mean (SD)	108.21 (16.09)	68.00 (22.64)	<0.001
FEV1**/FVC‖	Mean (SD)	79.61 (4.87)	55.80 (11.60)	<0.001
Bronchoreversibility	Yes	0 (0.0%)	9 (15.5%)	<0.001
Ejection fraction	Mean (SD)	57.36 (7.60)	55.63 (10.18)	0.27
Diastolic function	Normal	33 (47.8%)	13 (27.7%)	0.029
Heart failure	Normal	33 (47.1%)	13 (26.5%)	0.023
TAPSE¶ (mm)	Mean (SD)	22.61 (4.12)	21.49 (3.92)	0.15
	Normal	68 (95.8%)	44 (93.6%)	0.60
Pulsed Doppler S wave (cm/s)	Mean (SD)	14.25 (2.80)	14.30 (3.32)	0.92
	Normal	72 (98.6%)	48 (96.0%)	0.35
RV# fractional area change (%)	Mean (SD)	43.09 (5.50)	38.70 (6.89)	<0.001
	Normal	63 (96.9%)	36 (78.3%)	0.002
RV# basal diameter (mm)	Mean (SD)	34.40 (4.88)	36.74 (5.91)	0.023
	Normal	70 (95.9%)	38 (76.0%)	0.001
RV# mid diameter (mm)	Mean (SD)	28.88 (5.18)	30.00 (6.05)	0.27
	Normal	62 (84.9%)	40 (80.0%)	0.48
RV# longitudinal diameter (mm)	Mean (SD)	68.16 (5.91)	72.10 (7.19)	0.001
	Normal	74 (100.0%)	49 (98.0%)	0.22
RVOT## PLAX† (mm)	Mean (SD)	32.50 (3.82)	33.06 (4.76)	0.47
	Normal	42 (56.8%)	27 (55.1%)	0.86
PSAX‡ proximal diameters (mm)	Mean (SD)	35.16 (4.43)	36.70 (6.36)	0.30
	Normal	30 (58.8%)	11 (47.8%)	0.38
RVOT## PSAX‡ distal diameter (mm)	Mean (SD)	29.65 (3.16)	29.15 (2.43)	0.40
	Normal	15 (21.1%)	10 (25.6%)	0.59
TRV§ (m/s)	Mean (SD)	2.37 (0.33)	2.75 (0.48)	<0.001
RVOT† VTI§§ (cm)	Mean (SD)	16.32 (2.56)	15.50 (2.39)	0.09
Pulmonary vascular resistance on echocardiography (WU)	Mean (SD)	1.63 (0.33)	1.98 (0.46)	<0.001
	Normal	30 (51.7%)	8 (22.9%)	0.006

**COPD: Chronic obstructive pulmonary disease, **FEV1: Forced expiratory volume during the 1st second, ‖FVC: Forced vital capacity, ¶TAPSE: Tricuspid annular plane systolic excursion, #RV: Right ventricular, ##RVOT: Right ventricular outflow tract, †PLAX: Parasternal long axis, ‡PSAX: Parasternal short axis, §TRV: Tricuspid regurgitation velocity, §§VTI: Velocity time integral, PFT: Pulmonary function testing, SD: Standard deviation*

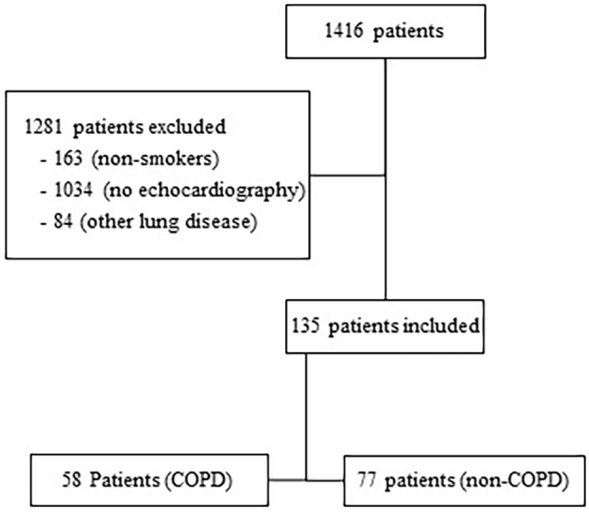

Figure 1. Flowchart for patient recruitment
COPD: Chronic obstructive pulmonary disease

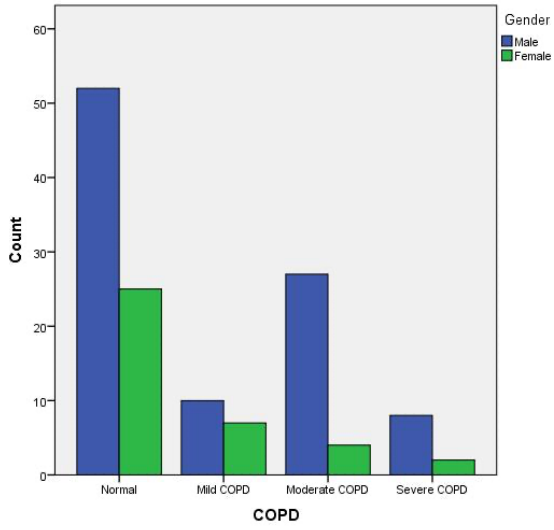

Figure 2. Distribution of gender among involved patients. Blue: Male, Green: Female.
COPD: Chronic obstructive pulmonary disease

First, we divided our patients into those with COPD and those without COPD. Next, we compared the demographics (age, smoking, sex) and the measured or calculated cardiac function parameters as observed by echocardiography [ejection fraction (EF), diastolic function, TAPSE, pulsed Doppler S' wave, RV FAC, the RV basal, mid, and longitudinal diameters, RVOT PLAX, RVOT PSAX proximal and distal diameters, and PVR as calculated using the TRV and VTI]. These comparisons are tabulated in Table 1. Across the 2 groups, there was no statistically significant difference in terms of sex, smoking more than 50 pack years, EF, TAPSE (scale and categorical), pulsed Doppler S' wave (scale and categorical), RV mid-diameter (scale and categorical), RV longitudinal diameter (categorical), RVOT PLAX (scale and categorical), and PSAX proximal and distal diameters (scale and categorical) with an unadjusted Pearson's chi-square with p-values of 0.20, 0.54, 0.27, 0.15, and 0.60, 0.92 and 0.35, 0.27 and 0.48, 0.22, 0.47 and 0.86, 0.30 and 0.38, and 0.40 and 0.59, respectively.

On the other hand, we also observed statistically significant differences between participants without COPD and those with COPD. COPD was associated in a statistically significant manner with increased age (scale and categorical ≥70 years old), smoking (scale), diastolic dysfunction, systolic HF, RV FAC (scale and categorical), RV basal (scale and categorical) and longitudinal (scale) diameters, and PVR (scale and categorical) with an unadjusted Pearson's chi-square with a p-value of <0.001 and <0.001, 0.028, 0.029, 0.023, <0.001 and 0.002, 0.023 and 0.001, 0.001, and <0.001 and 0.006, respectively. We then performed a multivariate logistic regression, as shown in Table 2 to adjust for age, gender, smoking, and systolic and diastolic HF.

In this multivariate analysis, when adjusting for age, gender, smoking, and systolic and diastolic HF: RV FAC's (scale), and RV basal (scale and categorical) and longitudinal (scale) diameters with COPD was no longer detected in a statistically significant manner. TAPSE's (scale and categorical), pulsed Doppler S wave (scale), RV mid-diameter (scale and categorical), RVOT PLAX's (scale and categorical), and PSAX proximal and distal diameters' (scale and categorical) association with COPD, after adjusting for confounders, failed again to reach statistical significance. However, PVR (scale and categorical) was associated with COPD in a statistically significant manner after adjusting for age, gender,

Table 2. Multivariate regression of COPD and different outcomes while adjusting for age, gender, smoking, systolic and diastolic heart failure

	COPD* (reference: normal)			
		95% CI		
Continuous Outcomes	**Exp (β)**	**Lower**	**Upper**	**p-value**
TAPSE** (mm)	0.49	0.21	1.13	0.09
Pulsed Doppler S wave (cm/s)	0.86	0.43	1.73	0.68
RV‖ fractional area change (%)	0.31	0.07	1.40	0.13
RV‖ basal diameter (mm)	2.89	0.88	9.58	0.08
RV‖ mid diameter (mm)	1.58	0.45	5.58	0.47
RV‖ longitudinal diameter (mm)	2.75	0.68	10.91	0.15
RVOT¶ PLAX## (mm)	0.88	0.33	2.39	0.80
PSAX# proximal diameters (mm)	4.31	0.89	20.91	0.07
RVOT¶ PSAX# distal diameter (mm)	0.66	0.34	1.26	0.20
Pulmonary vascular resistance on echocardiography (WU)	1.11	1.02	1.21	0.02
		95% CI		
Categorical Outcomes	**OR**	**Lower**	**Upper**	**p-value**
TAPSE** (mm) (reference: normal)	2.06	0.65	6.52	0.22
RV‖ basal diameter (mm) (reference: normal)	1.93	0.96	3.88	0.06
RV‖ mid diameter (mm) (reference: normal)	1.02	0.58	1.78	0.95
RVOT¶ PLAX## (mm) (reference: normal)	0.91	0.59	1.39	0.65
PSAX# proximal diameters (mm) (reference: normal)	1.80	0.91	3.58	0.09
RVOT¶ PSAX# distal diameter (mm) (reference: normal)	0.49	0.23	1.01	0.052
Pulmonary vascular resistance on echocardiography (WU) (reference: normal)	1.99	1.15	3.46	0.02

**COPD: Chronic obstructive pulmonary disease, **TAPSE: Tricuspid annular plane systolic excursion, ‖RV: Right ventricular, ¶RVOT: Right ventricular outflow tract, #PSAX: Parasternal short axis, ##PLAX: Parasternal long axis*

smoking, and systolic and diastolic HF. Nonetheless, after adjusting for the Bonferroni correction, we found that the adjusted association between PVR and COPD was no longer statistically significant. The adjusted OR were 0.31 [95% confidence interval (CI): 0.07-1.40; p=0.13], 2.89 (95% CI: 0.88-9.58; p=0.08) and 1.93 (95% CI: 0.96-3.88; p=0.06), 2.75 (95% CI: 0.68-10.91; p=0.15), 0.49 (95% CI: 0.21-1.13; p=0.09) and 2.06 (95% CI: 0.65-6.52; p=0.22), 0.86 (95% CI: 0.43-1.73; p=0.68), 1.58 (95% CI: 0.45-5.58; p=0.47) and 1.02 (95% CI: 0.58-1.78; p=0.95), 0.88 (95% CI: 0.33-2.39; p=0.80) and 0.91 (95% CI: 0.59-1.39; p=0.65), 4.31 (95% CI: 0.89-20.91; p=0.07) and 1.80 (95% CI: 0.91-3.58; p=0.09), 0.66 (95% CI: 0.34-1.26; p=0.20) and 0.49 (95% CI: 0.23-1.01; p=0.052), and 1.11 (95% CI: 1.02-1.21; p=0.02) and 1.99 (95% CI: 1.15-3.46; p=0.02) respectively.

Discussion

Our study revealed an association between COPD and PVR. Moreover, COPD is associated with the RV diameter parameters. A greater powered study can better reveal these associations in addition to the association between COPD and TAPSE, which was too weak for our study power to detect.

From the results we have observed, we can say that the unadjusted PVR, RV diameters, and RV FAC were associated with the presence of COPD. The mean RV FAC difference between those with and without COPD in our study was 4%, with a standard deviation (s) of 7% for the COPD group. COPD had a smaller RV FAC. Qualitatively, these findings are similar to the results of Gokdeniz et al.[8]. However, they had a mean difference of 8% with

a standard deviation (s) of 7% for the COPD group. The difference in the means between the two studies cannot be reconciled based on the standard errors of the means, which account for approximately 1% in both studies. In addition, Gokdeniz et al.[8] had a greater RV FAC for the COPD group compared with the RV FAC observed in patients with COPD in our study (44% versus 39%). The unadjusted PVR appears to have the most significant association.

Furthermore, because TAPSE is associated with 6MWT, as we previously noted above, we wanted to examine its association with COPD in our data[7,8]. However, our data did not support the existence of such an association. The mean TAPSE difference between those with and without COPD in our study was 1 mm (0.001 m), with a standard deviation (s) of 4 mm (0.004 m). COPD had a smaller TAPSE. Other studies in the literature report a more considerable TAPSE difference between the two groups [2-6 mm (0.002-0.006 m)][8-10]. As our study was based on the aforementioned data, we ended up being underpowered to detect a TAPSE difference between the two groups.

On the other hand, the increase in PVR was associated with increased odds of having COPD, after adjusting for age, gender, smoking, and systolic and diastolic HF. However, its significance was undermined when considering the Bonferroni correction. The variables RV FAC, RV diameters, and PVR are interrelated and were all associated with COPD in the unadjusted analysis. From our data, we see that the intertwined relationship between the right side of the heart and the lung is now more obvious.

To move a step further, we subdivided our data into COPD categories based on the GOLD criteria to distinguish RV dysfunction as a marker of early COPD as compared to a marker of disease progression. However, the results observed were not statistically significant.

Study Limitations

When interpreting this study for external validity, the reader should consider that this is a retrospective cross-sectional study. Not all patients with COPD undergo an echocardiogram. Consequently, it is reasonable to believe that those who undergo an echocardiogram may have a different set of characteristics from the average COPD patient. Hence, the study findings might not be representative of all COPD patients, limiting the generalizability of the results. This selection bias should be kept in mind. Furthermore, the cardiologist reviewed the echocardiograms retrospectively. This allowed for the presence of poor-quality images, which limited our assessment of certain parameters.

Moreover, because the parameters observed in the study had a high degree of variability, the number of patients included in the study was not ideal to allow for a high power. Hence, when we failed to reject a null hypothesis; we also fell short of rejecting the presence of a clinically significant difference. Due to the limited sample size, the study did not collect data on potential confounding factors such as comorbidities and medication use, which could have affected the results. Moreover, the use of an echocardiogram as a measure of RV dysfunction is not ideal because of the presence of inter-operator variability. A more reliable measurement tool for RV dysfunction would help boost the power of limiting the variability of its measurements. However, such tools are seldom used. Cardiac magnetic resonance (CMR) is widely recognized as the gold standard for evaluating RV function because of its superior accuracy and comprehensive assessment capabilities[13-15]. However, despite its advantages, CMR is not routinely used in clinical practice for RV evaluation. Cost, availability, technical complexities in image acquisition, and contraindications for certain patients are some of the reasons why alternative methods like echocardiography are often used instead.

Furthermore, it is important to note that current guidelines categorize COPD based on the degree of airflow limitation noted on spirometry, but also add other dimensions by factoring both the number of exacerbations and symptoms. accounting for these factors would be quite difficult in our retrospective study. Therefore, we limited our assessment of COPD severity to the old criteria that

relied only on the degree of airflow limitation. In addition, smoking history is subject to recall bias. Furthermore, our study was based on measurements taken at a single center (AUBMC). We believe that a multicenter study would allow for a more robust measurement by accounting for center-specific variability and any genetic variability that may be present. Finally, a prospective study has better prospects in establishing causality and observing timeline changes in RV dysfunction in patients with COPD. A prospective study would also help better identify patients who are normal. The reason behind this is that patients without COPD have undergone both PFTs and echocardiograms for medical reasons. This inserts doubt into how "normal" these patients actually were.

Conclusion

Our study shows the notion that RV dysfunction is associated with COPD. Our study establishes such an association with multiple cardiac markers; however, we were unable to pinpoint a specific marker that clearly delineates the difference between patients with and without COPD. Further research into the timeframe of this association would help us differentiate it as being an early marker or a late marker. An early marker would help detect COPD early and treat it early to reduce its burden. A late marker would help guide therapy to avoid or dampen disease progression. Nonetheless, further knowledge would improve our patients' care and hopefully provide them with a better quality of life. A prospective study following patients using advanced cardiac imaging technologies and spirometry would help put things into perspective.

Ethics

Ethics Committee Approval: Ethical committee approval was obtained from the Institutional Review Board (IRB) of American University of Beirut (approval no.: BIO-2018-0119, date: 11.07.2018).

Informed Consent: The need for patients' informed consent was expedited by the IRB.

Authorship Contributions

Concept: Sleiman W, Khalil PB, Refaat MM, Design: Sleiman W, Khalil PB, Refaat MM, Data Collection and/or Processing: Sleiman W, Zgheib A, Zakharia A, Analysis and/or Interpretation: Jalloul J, Makki M, Tamim H, Critical Review: Sleiman W, Jalloul J, Zgheib A, Zakharia A, Makki M, Tamim H, Khalil PB, Refaat MM, Writing: Sleiman W, Jalloul J, Zgheib A, Zakharia A, Makki M, Tamim H, Khalil PB, Refaat MM.

Conflict of Interest: The authors declare no conflicts of interest concerning the authorship or publication of this article.

Financial Disclosure: The authors declare that this study has received no financial support.

References

1. Sin DD, Man SF. Why are patients with chronic obstructive pulmonary disease at increased risk of cardiovascular diseases? The potential role of systemic inflammation in chronic obstructive pulmonary disease. Circulation 2003;107:1514-19.
2. Agusti A, Faner R. Systemic inflammation and comorbidities in chronic obstructive pulmonary disease. Proc Am Thorac Soc 2012;9:43-6.
3. Mannino DM, Ford ES, Redd SC. Obstructive and restrictive lung disease and markers of inflammation: data from the Third National Health and Nutrition Examination. Am J Med 2003;114:758-62.
4. Sidney S, Sorel M, Quesenberry Jr CP, DeLuise C, Lanes S, Eisner MD. COPD and incident cardiovascular disease hospitalizations and mortality: Kaiser Permanente Medical Care Program. Chest 2005;128:2068-75.
5. Curkendall SM, DeLuise C, Jones JK, et al. Cardiovascular disease in patients with chronic obstructive pulmonary disease, Saskatchewan Canada cardiovascular disease in COPD patients. Ann Epidemiol 2006;16:63-70.
6. Beghe B, Verduri A, Bottazzi B, et al. Echocardiography, spirometry, and systemic acute-phase inflammatory proteins in smokers with COPD or CHF: an observational study. PLoS One 2013;8:e80166.
7. Caminiti G, Cardaci V, Conti V, et al. Right ventricular systolic dysfunction is related to exercise intolerance in patients with chronic obstructive pulmonary disease. J Cardiopulm Rehabil Prev 2015;35:70-4.
8. Gokdeniz T, Kalaycioglu E, Boyaci F, et al. The BODE index, a multidimensional grading system, reflects impairment of right ventricle functions in patients with chronic obstructive pulmonary disease: a speckle-tracking study. Respiration 2014;88:223-33.
9. Kalaycıoğlu E, Gökdeniz T, Aykan AC, et al. Evaluation of left ventricular function and its relationship with multidimensional grading system (BODE Index) in patients with COPD. COPD 2015;12:568-74.

10. Geyik B, Tarakci N, Ozeke O, et al. Right ventricular outflow tract function in chronic obstructive pulmonary disease. Herz 2015;40:624-8.

11. Lang RM, Badano LP, Mor-Avi V, et al. Recommendations for cardiac chamber quantification by echocardiography in adults: an update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging. Eur Heart J Cardiovasc Imaging 2015;16:233-70.

12. Abbas AE, Fortuin FD, Schiller NB, Appleton CP, Moreno CA, Lester SJ. A simple method for noninvasive estimation of pulmonary vascular resistance. J Am Coll Cardiol 2003;41:1021-7.

13. Grothues F, Moon JC, Bellenger NG, Smith GS, Klein HU, Pennell DJ. Interstudy reproducibility of right ventricular volumes, function, and mass with cardiovascular magnetic resonance. Am Heart J 2004;147:218-23.

14. Maceira AM, Prasad SK, Khan M, Pennell DJ. Normalized left ventricular systolic and diastolic function by steady state free precession cardiovascular magnetic resonance. J Cardiovasc Magn Reson 2006;8:417-26.

15. Swift AJ, Rajaram S, Condliffe R, et al. Diagnostic accuracy of cardiovascular magnetic resonance imaging of right ventricular morphology and function in the assessment of suspected pulmonary hypertension results from the ASPIRE registry. J Cardiovasc Magn Reson 2012;14:40.