


## ORIGINAL ARTICLE

# Chronic Obstructive Pulmonary Disease with Incidence of Heart Failure and Its Influencing Factors

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## ABSTRACT

**Introduction:** Chronic obstructive pulmonary disease (COPD) is often associated with cardiovascular disease because it has the same risk factors as smoking. One of the cardiovascular complications in COPD is heart failure. Echocardiography examination is a tool to evaluate changes of the heart both anatomically and functionally. This study aimed to determine the relationship between COPD and heart failure by echocardiography examination in stable COPD patients.

**Methods:** This was a descriptive-analytic study using a cross-sectional design for COPD patients who visited the Lung Polyclinic of Arifin Achmad Hospital, Pekanbaru, Riau, which was conducted from November 2020 to March 2021. Subjects who met the inclusion criteria were examined by spirometry, chest X-rays, and echocardiography.

**Results:** In this study, there were 66 stable COPD subjects. It was found that 15.2% of subjects had right heart failure based on the tricuspid annular plain systolic excursion (TAPSE) assessment and 7.6% of the subjects had left heart failure based on the left ventricular ejection fraction (LVEF) value. Right ventricular dilatation ( $p = 0.000$ ), right ventricular dysfunction ( $p = 0.005$ ), and increased probability of pulmonary hypertension (PH) ( $p = 0.000$ ) were significantly associated with a decrease in the first second forced expiratory volume (FEV1).

**Conclusion:** The severity of COPD with FEV1  $<50\%$  had a significant relationship with dilatation, dysfunction of right ventricular, and increased the probability of incidence of PH based on parameters tricuspid regurgitation (TR). A history of exacerbations  $\geq 2$  times in a year caused right ventricular dilatation, decreased right ventricular function, and increased the probability of PH.

## INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a global health problem and is the fourth leading cause of death in the world. Many people die due to COPD or its complications.<sup>1</sup> The development of COPD causes progressive airflow limitation, air trapping, and pulmonary hyperinflation as well as increased pulmonary vascular pressure.<sup>1,2</sup> In addition to causing pulmonary abnormalities, COPD also has an impact on other organs known for systemic complications and comorbidity which contribute to prognosis, functional ability, the severity of COPD, and mortality.<sup>3</sup> COPD has blood vessels causing pulmonary hypertension (PH), cor

pulmonary, right ventricular dysfunction, and left ventricular dysfunction. The mortality rate in COPD patients increases due to the involvement of cardiovascular disorders such as ischemic heart disease.<sup>4</sup>

Echocardiography examination is a non-invasive examination procedure which can be used to evaluate cardiac changes both anatomically and functionally tricuspid such as assessing right ventricular function, right ventricular filling pressure, tricuspid regurgitation (TR), left ventricular function, and cardiac valve.<sup>5,6</sup> This assessment is very important to determine cardiac changes which occur as early as possible in stable COPD patients, hence the selection and administration of appropriate therapy can be started, can be assessed

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prognosis, and can be given secondary prevention measures to improve the patient's quality of life. This study aimed to determine the prevalence of heart failure in stable COPD patients and to see the relationship between severity of COPD based on Global Initiative for Chronic Obstructive Lung Disease (GOLD) with dimension, function, and cardiac pressure.

## METHODS

This was a descriptive-analytic study with cross-sectional design which was conducted on stable COPD patients who visited the Lung Polyclinic of Arifin Achmad Hospital, Pekanbaru, Riau. This study was conducted from November 2020 to March 2021. This study had passed an ethical review and had been approved by the Ethical Review Board for Medicine and Health Research, Faculty of Medicine, University of Riau (No. B/004/UN19.5.1.1.8/UEPKK/2021).

The inclusion criteria consisted of all mild to severe COPD patients, male or female who visited the Lung Polyclinic of Arifin Achmad Hospital, Pekanbaru, Riau and were willing to participate in this study by signing the informed consent. Exclusion criteria were patients with acute coronary syndrome, moderate to severe mitral stenosis, all pulmonary diseases other than COPD as evidenced by chest X-ray with abnormalities in the lung parenchyma and pleura, and poor echocardiography window.

All subjects who met the inclusion criteria underwent examinations such as anamnesis, physical examination, spirometry, chest X-ray, blood pressure measurement, electrocardiography, and echocardiography. A spirometry examination was performed to assess the severity of COPD based on the 2019 GOLD. The patient also performed a chest X-ray examination to rule out lung diseases other than COPD. Then the patient was sent to the Polyclinic Cardiology for tests to measure blood pressure, electrocardiography, and echocardiography. Echocardiography examination was performed to assess the dimensions of RV and LV, right ventricular function through the parameters of tricuspid annular plain systolic excursion (TAPSE) (<1.7 mm), and right ventricular function through the ejection fraction value (LVEF <40%).

The data obtained was analyzed with statistical package for social science (SPSS) software 2.6. Data analysis in this study used chi-square because the variables being compared were categorical scales. The numerical data for each variable was calculated as mean and standard deviation. The data which was and was not categorized was normally distributed using medians and maximum and minimum values. Bivariate data were tested with chi-square and if they did not meet the requirements, then Fisher's test was performed. The

analysis was continued with a logistic regression test for the bivariate test results that met the multivariate requirements, namely  $p < 0.25$ .

## RESULTS

The total sample collected during the study period and had met the inclusion criteria was 66 stable COPD subjects. Male patients were the largest subject at 93.9% and the median age of the subject in the study was 65 years old with the youngest subject age in this study being 45 years old and the oldest was 84 years old. The severity of COPD based on GOLD was found to be 56.1% GOLD II, 39.4% GOLD III, and 4.5% GOLD IV. The echocardiographic findings of the subjects found that 22.7% had RV dilatation, 19.7% had LV dilatation, 15.2% had RV dysfunction, and 7.6% had LV dysfunction. The basic characteristics and echocardiographic findings of the subjects are shown in Table 1.

### Relationship of COPD severity with dimensions of cardiac ventricles

In this study, it was found that 22.7% of subjects had RV dilatation and 19.7% of subjects had LV dilatation as shown in Table 2. Dilatation of RV was found in GOLD II 5.4%, GOLD III 38.5%, and GOLD IV 100% in COPD subjects. The severity of COPD was significantly associated with RV dilatation ( $p = 0.000$ ). Subjects were then divided into two groups, namely the mild-moderate COPD group ( $FEV1 \geq 50\%$  pred) and the severe COPD group ( $FEV1 < 50\%$  pred). Dilatation of RV was found to be 44.8% in  $FEV1 < 50\%$  pred ( $p = 0.000$ ) and a prevalence ratio (PR) of 8.3 (95% CI = 2.03-33.87) which means that the prevalence of RV dilatation was found to be 8.3 times more in the severe COPD group than in the mild COPD group. The left-sided ventricular showed no significant relationship between the degree of severity in COPD with dilatation of LV ( $p = 0.300$  and  $p = 0.623$ ).

### Relationship of COPD severity with functions of cardiac ventricles

Dysfunction of RV was found in 15.2% and dysfunction of LV in 7.6% of stable COPD subjects as shown in Table 3. Dysfunction of RV was found in GOLD II 2.7%, GOLD III 23.1%, and GOLD IV 100%. This shows that the severity of COPD is significantly associated with decreased RV function ( $p = 0.000$ ). Dysfunction of RV was also found in 31% of  $FEV1 < 50\%$  pred with  $p = 0.005$  and PR 11.5 (1.54-85.53). This means that the prevalence of dysfunction of RV was found to be 11.5 times more in the severe COPD group than in the mild-moderate COPD group. In the left-sided ventricular, there was no significant relationship between the severity of COPD and the dysfunction of LV ( $p = 0.143$  and  $p = 0.222$ ).

**Table 1.** Basic characteristics and echocardiography findings in stable COPD patients

Characteristics of patients	COPD Number of Case (n)	Percentage (%)
Gender		
Male	62	93.9
Female	4	6.1
Age		
≥65 years old	35	53
<65 years old	31	47
Smoking history		
Former smoker	58	87.9
Active smoker	5	7.6
Not a smoker	3	4.5
Brinkman Index		
Mild	6	9.1
Moderate	8	12.1
Severe	52	78.8
Exacerbation and number of exacerbation in 1 year		
≥2 times in year	50	75.8
0-1 times in a year	16	24.2
CAT score		
Score ≥10	51	77.3
Score <10	15	22.7
mMRC score		
Score ≥2	48	72.7
Score 0-1	18	27.3
COPD severity is based on GOLD		
GOLD I	37	56.1
GOLD II	26	39.4
GOLD III	3	4.5
GOLD IV		
Hypertension		
Yes	20	30.3
Not	46	69.7
Diabetes mellitus		
Yes	4	6.1
Not	62	93.9
<b>Characteristics of echocardiography findings in COPD subjects</b>		
RV dimensions		
RV dilatation	15	22.7
Normal	51	77.3
LV dimensions		
LV dilatation	13	19.7

Characteristics of patients	COPD Number of Case (n)	Percentage (%)
Normal	53	80.3
RV function (TAPSE)		
Decreased	10	15.2
Normal	56	84.8
LV function (LVEF)		
Decreased	5	7.6
Normal	61	92.4
Tricuspid valve		
Regurgitation	28	42.4
Normal	38	57.6
Degree of TR		
Mild TR	9	13.6
Moderate TR	16	24.2
Severe TR	3	4.6
Normal	38	57.6
Mitral valve		
Regurgitation	12	18.2
Normal	54	81.8
Pulmonary valve		
Regurgitation	8	12.1
Normal	58	87.9
Aortic valve		
Regurgitation	4	6.1
Normal	62	93.9
Pulmonary artery in diameter		
Dilatation	20	30.3
Normal	46	69.7

### **Relationship of severity COPD with the probability of PH based on TR**

A total of 43.4% of subjects experienced TR, namely 13.6% mild TR, 24.2% moderate TR, and 4.6% severe TR. Based on the findings of TR, it was found that there were 25% of subjects with low probability PH, 32.1% with intermediate probability PH, and 42.9% with high probability PH. Based on the severity of COPD, it was found 18.9% in GOLD II, 64.3% in GOLD III, and 100% in GOLD IV. This shows that the severity of

**Table 2.** Relationship of severity of COPD with dimensions cardiac ventricular

Severity of COPD	RV dilatation (n = 15)	p	PR (95% CI)	LV dilatation (n = 13)	p	PR (95% CI)
GOLD IV (n = 3)	3 (100%)	<b>0.000</b>		0	0.300	
GOLD III (n = 26)	10 (38.5%)			7 (26.9%)		
GOLD II (n = 37)	2 (5.4%)			6 (16.2%)		
FEV1 <50% pred (n = 29)	13 (44.8%)	<b>0.000</b>	<b>8.3</b>	7 (24.1%)	0.623	1.5
FEV1 ≥50% pred (n = 37)	2 (5.4%)		<b>(2.03-33.87)</b>	6 (16.2%)		<b>(0.56-3.95)</b>

**Table 3.** Relationship of severity of COPD with cardiac ventricular functions

Severity of COPD	RV dysfunction (n = 10)	p	PR (95% CI)	LV dysfunction (n = 5)	p	PR (95% CI)
GOLD IV (n = 3)	3 (100%)	<b>0.000</b>		0	0.143	
GOLD III (n = 26)	6 (23.1%)			4 (15.4%)		
GOLD II (n = 37)	1 (2.7%)			1 (2.7%)		
FEV1 <50% pred (n = 29)	9 (31%)	<b>0.005</b>	<b>11.5</b>	4 (13.8%)	0.222	5.1
FEV1 ≥50% pred (n = 37)	1 (2.7%)		<b>(1.54-85.53)</b>	1 (2.7%)		<b>(0.60-43.23)</b>

**Table 4.** Relationship of COPD severity based on GOLD with a degree of probability of PH

Subject Characteristics	Probability of PH			p
	High prob n = 12	Intermediate prob n = 9	Low prob n = 7	
GOLD IV (n = 3)	3 (100%)	0	0	0.000
GOLD III (n = 26)	8 (30.8%)	7 (26.9%)	3 (11.5%)	
GOLD II (n = 37)	1 (2.7%)	2 (5.4%)	4 (10.8%)	

**Table 5.** Relationship of COPD based on severity of airflow limitation with probability of PH

Subject Characteristics	Probability of PH		p	PR (95% CI)
	Yes n = 28	Normal n = 38		
FEV1 <50% pred, (n = 29)	21 (72.4%)	8 (27.6%)	<b>0.000</b>	<b>3.8 (1.89-7.74)</b>
FEV1 ≥50% pred, (n = 37)	7 (18.9%)	30 (81.1%)		

**Table 6.** Relationship of risk factors with dimensions, function of RV, and probability of PH

Risk factor	RV dilatation		RV dysfunction		Probability of PH	
	p	PR (95% CI)	p	PR (95% CI)	p	PR (95% CI)
FEV <50% pred	<b>0.000</b>	<b>8.3 (2.03-33.87)</b>	<b>0.005</b>	<b>11.5 (1.54-85.53)</b>	<b>0.000</b>	<b>3.8 (1.89-7.74)</b>
Gender	1.000	0.9 (0.16-5.24)	1.000		0.837	1.7 (0.31-9.74)
Age	0.134	2.4 (0.86-6.87)	0.410	2.1 (0.58-7.31)	0.410	1.3 (0.76-2.46)
Smoking history	1.000		1.000		1.000	1.2 (0.25-6.53)
History of exacerbations ≥2 times in a year	<b>0.000</b>	<b>6.3 (2.51-15.59)</b>	<b>0.001</b>	<b>7.3 (2.13-24.94)</b>	<b>0.004</b>	<b>3.9 (1.32-11.45)</b>
Hypertension	1.000	1.2 (0.45-2.93)	0.726	1.5 (0.48-4.85)	0.582	1.2 (0.72-2.25)
Diabetes mellitus	0.567		1.000		0.316	

**Table 7.** Risk factors affecting RV dilatation, RV dysfunction, and probability of HP via multivariate logistic regression analysis

Risk factors associated with RV dilatation	Significance	Odd ratio	95% CI for Exp(B)	
			Lower	Upper
FEV1 <50% pred	0.091	5.250	0.768	35.891
History of exacerbations ≥2 times in a year	0.040	5.556	1.078	28.635
Age ≥65 years old	0.250	2.389	0.542	10.520
Risk factors associated with RV dysfunction	Significance	Odd ratio	95% CI for Exp(B)	
			Lower	Upper
FEV1 <50% pred	0.140	6.545	0.541	79.232
History of exacerbations ≥2 times in a year	0.001	12.185	2.641	56.217
Risk factors associated with probability of PH	Significance	Odd ratio	95% CI for Exp(B)	
			Lower	Upper
FEV1 <50% pred	0.139	3.150	0.690	14.390
History of exacerbations ≥2 times in a year	0.001	11.250	3.535	35.799

COPD is significantly associated with an increase in the probability of PH with  $p = 0.000$  (Table 4). The bivariate test showed that in the COPD group with severe degrees of COPD, the probability of PH was 72.4% with  $p = 0.000$  and PR 3.8 (1.89-7.74). This shows that the severity of COPD with an FEV1 <50% predominantly causes an increase in the probability prevalence of PH 3.8 times more than in the mild-moderate COPD group (Table 5).

#### Relationship of a risk factor with dimensions, the function of RV, and probability of PH

Bivariate analysis between risk factors and their relationship with the dimensions, function of RV, and probability of PH found that a history of exacerbations

≥2 times in a year was a factor that significantly influenced the increase in the prevalence of RV dilatation ( $p = 0.000$ , PR 6.3 (2.51-15.59), RV dysfunction ( $p = 0.001$ , PR 7.3 (2.13-24.94), and probability of PH ( $p = 0.004$ , PR 3.9 (1.32-11.45) compared to the group without exacerbations or the number of exacerbations <2 times in a year (Table 6).

#### Logistic regression multivariate analysis of risk factor with dimensions, the function of RV, and probability of PH

Variable factors associated with RV dilatation, RV dysfunction, and increased incidence of PH (Table 6) were included in the multivariate logistic regression analysis and it was found that a history of exacerbations

$\geq 2$  times in a year was the only parameter independently associated with RV dilatation ( $p = 0.040$ , OR 5.6 (1.078-28.635), RV dysfunction ( $p = 0.001$ , OR 12.2 (2.641-56.217), and increased probability of PH ( $p = 0.001$ , OR 11.2 (3.535-35.799) (Table 7).

## DISCUSSION

### Prevalence of heart failure

Assessment of right heart failure in this study used an echocardiography modality by assessing the TAPSE parameter to obtain right ventricular systolic function. In this study, it was found that the prevalence of right heart failure was 15.2% from 66 stable COPD subjects. Putrawan, *et al.* found a prevalence of right heart failure which was not much different from this study of 11.4% of 70 stable COPD subjects using the TAPSE parameter.<sup>7</sup> Basak, *et al.* also found a decreased prevalence of RV systolic function with a TAPSE value of 16% in stable COPD patients. A decrease in the value of TAPSE was found to be 4.2% in GOLD II, 10.3% in GOLD III, and 37.9% in GOLD IV.<sup>4</sup> Tannus-Silva, *et al.* also found that 16% of 50 stable COPD patients with a mean of FEV1 value of 37.6% ( $\pm 19.3$ ) pred had RV dysfunction using TAPSE values.<sup>8</sup>

It is undeniable that COPD can cause heart failure, especially in the right heart. Hypoxic conditions, chronic hypoxemia, systemic inflammation, atherosclerotic processes, and endothelial dysfunction of the pulmonary artery cause increased pressure in the pulmonary arteries which triggers PH. This condition causes RV to increase its pressure to push blood into the arteries, increase muscle cells, and ultimately cause enlargement of RV. When RV loses its compensatory ability to maintain proper function to push blood into the pulmonary arteries due to high pulmonary vascular pressure, this condition results in right heart failure or cor pulmonary.<sup>9</sup>

The prevalence of left heart failure by assessing left ventricular ejection fraction (LVEF) in this study was found to be 7.6% and there was no statistically significant relationship between the severity of COPD with decreased left ventricular systolic function ( $p > 0.05$ ). The same results were found by Gupta, *et al.* who found a decrease in left ventricular systolic function of 7.5% in 40 stable COPD subjects and Putrawan who found a 5.7% prevalence of left heart failure in stable COPD subjects.<sup>7,10</sup> Buklioska-Ilievska D, *et al.* also found a prevalence of left heart failure by assessing left ventricular systolic function of 5.5% in 60 COPD patients.<sup>11</sup>

COPD does not directly cause left heart failure as it does in the right heart. However, left heart failure in COPD patients can occur because they have the same

risk factors, namely smoking, chronic hypoxia in COPD, local and systemic inflammation that can lead to an increase in atherosclerotic lesions which can lead to ischemic heart disease which leads to congestive heart failure.<sup>12</sup> The effect of COPD on RV causes changes in the dimensions of RV. This dimensional change causes a shift in the interventricular septum which changes the geometry of LV, thereby reducing left ventricular filling.<sup>13</sup>

In addition, hypoxia and hypercapnia in COPD also trigger the activity of the myocardial sympathetic nervous system, increasing heart rate, causing stress on LV wall, and followed by enlargement of LV which causes the heart to weaken, harden, and reduce the heart's function in pumping blood. This condition, if it continues, will cause left heart failure.<sup>14</sup>

### Relationship between lung function and the dimensions, function, and pressure of the heart's ventricles

In this study, it was found that the prevalence of RV dilatation was 22.7% and the prevalence of LV dilatation was 19.7% from 66 stable COPD subjects. Statistical calculations found a significant relationship between the severity of COPD based on GOLD and RV dilatation ( $p = 0.000$ ). Similar results were performed by Mohammed, *et al.* who found RV dilation in COPD patients by 18% and LV dilatation by 25% in COPD patients.<sup>15</sup> The study also found 44.8% RV dilatation in 29 subjects with FEV1  $< 50\%$  prediction and found a significant association between this group and changes in the dimensions of RV ( $p = 0.000$ ). Sekhar, *et al.* found a change in RV dimension in subjects with FEV1  $< 50\%$  predictive of 40%.<sup>16</sup> Pothal, *et al.* found that 30% of 80 COPD subjects had RV dilatation with 35.7% in 28 GOLD III subjects and 87.5% of 16 GOLD IV subjects.<sup>17</sup>

In this study, it was found that a decrease in RV function based on the TAPSE value was 15.2% and a decrease in left ventricular function based on an LVEF value of 7.6% in 66 stable COPD subjects. There was a significant relationship between the severity of COPD with decreased RV function ( $p = 0.000$ ). Basak, *et al.* also found a 16% prevalence of decreased RV systolic function with a distribution of 4.2% in 24 GOLD II subjects, 10.3% in 39 GOLD III subjects, and 37.9% in 29 GOLD IV subjects.<sup>4</sup> Tannus-Silva, *et al.* also found 8 subjects (16%) of 50 stable COPD patients with a mean FEV1 value of 37.6% ( $\pm 19.3$ ) pred who had RV dysfunction using TAPSE values.<sup>8</sup> Gupta, *et al.* found a decrease in LV systolic function of 7.5% in 40 stable COPD patients and Putrawan found a 5.7% prevalence of LV dysfunction in stable COPD subjects.<sup>7,10</sup>

Buklioska-Ilievska D, *et al.* also found a prevalence of left heart failure by assessing LV systolic dysfunction of 5.5% in 60 COPD patients.<sup>11</sup>

As previously explained, chronic hypoxia, which is identical in COPD patients, as well as local and systemic inflammation, are responsible for right heart disorders. Chronic hypoxia will cause pulmonary artery vasoconstriction and systemic inflammation will cause endothelial dysfunction. This condition causes intima hyperplasia and pulmonary artery smooth muscle hypertrophy leading to capillary bed damage. This causes an increase in pulmonary artery resistance, leading to PH. PH will cause an increase in RV afterload, hence RV myocardial wall pressure increases, which in turn causes RV dilatation and hypertrophy. The function of RV begins to decrease, resulting in right heart failure. Due to dilatation and hypertrophy of RV, LV is also affected due to ventricular interdependence and a shift in the interventricular septum. This condition causes changes in the dimensions of LV, both dilated and hypertrophied. Left ventricular function begins to decline and cardiac output is reduced, resulting in left heart failure.<sup>14</sup>

The latest guideline issued by ESC/ERS in 2015 stated that diagnosis of PH based on mean pulmonary artery pressure (MPAP) values using echocardiography is no longer recommended. This is because the assessment of the degree of mild or severe PH by echocardiography does not show the real thing in patient. The use of echocardiography is only limited in assessing the probability or likelihood of developing PH. The parameters used were TR plus other echo images determined by ESC/ERS, such as the ventricle, pulmonary artery, inferior vena cava, and right atrium. Right heart catheterization is the gold standard for diagnosing PH.<sup>18</sup>

In this study, 42.4% of subjects had a probability of developing PH based on TR parameters. Putrawan, *et al.* found that 58.6% of COPD subjects had a probability of incidence of PH.<sup>7</sup> In this study, it was found that 18.9% GOLD II, 69.2% GOLD III, and 100% GOLD IV experienced TR. This shows that the severity of COPD was significantly associated with an increased incidence of TR ( $p = 0.000$ ). Jain, *et al.* found that the incidence of TR in 60% of stable COPD patients with mild, moderate, severe, and very severe degrees was 58.3%, 60%, 60%, and 100% respectively, and found a significant relationship between the severity of COPD and the incidence of TR ( $p = 0.000$ ).<sup>19</sup> Kaur, *et al.* found that 72% of COPD subjects experienced TR with a distribution of 57.1% in GOLD II, 79.3% in GOLD III, and 100% in GOLD IV. The study also found a statistically significant positive correlation between TR

and the severity of COPD with a spearman's correlation coefficient of +0.387 and  $p$ -value = 0.005.<sup>20</sup>

There were no studies which linked the severity of COPD with the probability of PH based on TR parameters. The use of tricuspid valve parameter in assessing the probability of PH can be used as an early detection tool in stable COPD patients who are suspected of having PH, thus they do not fall into PH with the involvement of increased pulmonary artery pressure which in turn will lead to cor pulmonary or heart failure right.

### Relationship of exacerbation factors with dimensions, function, and right ventricular pressure

The multivariate test in this study found that the exacerbation factor as many as  $\geq 2$  times in a year was an independent factor that caused problems in the right heart, namely RV dilation ( $p = 0.040$ , OR 5.6 (1.078-28.635)), RV dysfunction ( $p = 0.001$ , OR 12.2 (2.641-56.217)), and an increased probability of PH ( $p = 0.001$ , OR 11.2 (3.535-35.799)). Ozben, *et al.* found that acute exacerbations of COPD significantly lead to an increase in pulmonary artery pressure which can increase RV afterload, resulting in RV systolic dysfunction (OR 9.3 95% CI = 1.86-46.68), while in LV there was no significant relationship between changes in dimensions or decreased LV function ( $p > 0.05$ ).<sup>21</sup> Terzano, *et al.* also found that COPD patients with a history of exacerbations caused a decrease in TAPSE values by  $14 \pm 6$  mm in moderate COPD and by  $11.2 \pm 2.4$  mm in severe COPD with  $p = 0.05$ .<sup>22</sup>

Repeated exacerbations cause the pulmonary artery pressure to increase, hence the right ventricular tension continues to increase, causing impaired right ventricular function.<sup>23,24</sup> Medrek, *et al.* with a retrospective cohort study found that COPD patients with a history or number of exacerbations  $> 1$  time in a year had an increased incidence of PH with  $p = 0.0001$  and OR 1.11 (95% CI = 1.101-1,116).<sup>25</sup> El-Shabrawy, *et al.* also found 84 subjects had a history of exacerbations  $\geq 2$  times in a year and 64.8% of 108 COPD subjects influence the incidence of PH.<sup>26</sup>

### CONCLUSION

This study found a significant relationship between the severity of stable COPD based on GOLD with changes in anatomy, function, and right ventricular pressure. Patients with FEV1 $< 50\%$  pred caused RV dilatation, RV dysfunction, and an increase in the probability of PH. The prevalence of right heart failure based on the TAPSE parameter found in this study was 15.2% and the prevalence of left heart failure based on

the ejection fraction (LVEF) found in this study was 7.6% of 66 COPD subjects. A history of exacerbations with the number of exacerbations  $\geq 2$  times in a year is an independent factor that causes RV dilatation, RV dysfunction, and increases the probability of PH.

The use of tricuspid valve parameters in assessing the probability of PH can be used as an early detection tool in all COPD patients suspected of having PH, especially patients with COPD with GOLD III and GOLD IV or FEV1 <50% pred and COPD patients who have a history of exacerbations  $\geq 2$  times in a year, thus stable COPD patients do not fall in a condition of PH with the involvement of an increase in pulmonary artery pressure which in turn will lead to cor pulmonary or right heart failure.

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### Conflict of Interest

The author stated there is no conflict of interest in this study.

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### Authors' Contributions

Writing manuscript, gathering samples, designing experiments, making tables and figures, interpreting data: AWA. Reviewing and revising, interpreting data, designing experiments: A and FY. Reviewing and revising: DS and Z. All authors have read and agreed to the published version of the manuscript.

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