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Original Research Article

Cardiac Assessment of Chronic Obstructive Pulmonary Disease Patients by ECHO and Its Association with Different Grades of Severity of Chronic Obstructive Pulmonary Disease

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Abstract

Background and Aim: COPD has significant impacts on cardiac functions, affecting the right ventricle, left ventricle, and pulmonary blood vessels. Cardiac involvement is a significant factor contributing to the increased mortality associated with COPD. Echocardiography is a valuable tool for quickly and accurately assessing cardiac changes. It is a noninvasive and portable method that provides reliable results. Our study aimed to evaluate the cardiac changes associated with COPD using echocardiography. Additionally, we sought to determine the relationship between echocardiographic findings and the varying degrees of COPD severity.

Material and Methods: A study was conducted on 100 patients with COPD who received treatment at a Tertiary Care Teaching Institute in India **from January 2022 to January 2023.**. A group of 100 COPD patients underwent spirometry to determine their stage, and echocardiography was used to evaluate their condition. The ECHO report assessed several parameters, including RV enlargement, tricuspid regurgitation, RA enlargement, pulmonary arterial hypertension, and LV function as indicated by LV ejection fraction.

Results: In our study, we found that the percentages of patients with mild, moderate, severe, and very severe COPD were 4%, 28%, 58%, and 10%, respectively. During the evaluation of COPD using echocardiography, it was found that 24% of cases had normal echocardiographic parameters. In 70 out of 100 cases, pulmonary hypertension was observed. The prevalence of mild, moderate, and severe PH in these cases were 0%, 50%, 79.3%, and 100%, respectively. In 46% of patients, the ECHO revealed an enlargement of the right ventricle. In 14% of patients, the ECHO revealed an enlargement of the right atrium. Tricuspid regurgitation (TR) was found in 72% of the cases, as determined by measurements.

Conclusion: The presence of pulmonary arterial hypertension, right ventricular enlargement, right atrial enlargement, and tricuspid regurgitation on echocardiography is closely associated with the severity of COPD. These conditions become more prevalent as the severity of COPD increases. It is worth noting that the risk of cardiac dysfunction tends to rise as COPD

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becomes more severe. Echocardiography can be a valuable tool for examining the cardiac complications associated with COPD.

Key Words: Chronic obstructive pulmonary disease, Echocardiography, Pulmonary Hypertension Tricuspid Regurgitation

1. Introduction

COPD has significant impacts on cardiac function, affecting the right ventricle, left ventricle, and pulmonary blood vessels. COPD is a prevalent disease that can be prevented and treated. It involves a chronic inflammatory response in the airways and lungs, leading to persistent airflow limitation. This condition tends to worsen over time and is often caused by exposure to harmful particles or gases. Exacerbations and comorbidities play a significant role in determining the overall severity experienced by individual patients.

Based on data from the World Bank, there is an expected shift in its ranking as a cause of mortality and morbidity. In 2000, it was the 4th most frequent cause of mortality and the 12th most frequent cause of morbidity. However, by 2020, it is projected to become the 3rd leading cause of mortality and the 5th leading cause of morbidity.[1,2] COPD is known to have various extrapulmonary effects, with cardiac manifestations being the most prevalent. Cardiovascular disease is responsible for about 50% of hospitalisations and nearly one third of all deaths, when the forced expiratory volume in one second (FEV1) is greater than 50% of the predicted value.[3] Cardiovascular disease is responsible for a significant percentage of deaths in individuals with advanced COPD.[4] Individuals with COPD experience a range of cardiovascular complications, including pulmonary hypertension, cor pulmonale, and dysfunction in both the right and left ventricles.

The link between cardiovascular disease and COPD can be attributed to various risk factors, such as smoking, the overall impact of inflammation on the body, compromised vascular function, and lung hyperinflation.[5,6,7] COPD is associated with significant cardiac manifestations. Cardiovascular disease is responsible for about half of all hospitalisations and nearly a third of all deaths among COPD patients with FEV1 greater than 50% of the predicted value.[8] Cardiovascular disease is responsible for 20%-25% of all deaths in more advanced cases of COPD.[9] There are several cardiac manifestations associated with COPD. Impairment of right ventricular function and pulmonary blood vessels often complicate the clinical course of COPD and have been found to have a negative impact on survival. Pulmonary circulation undergoes significant structural changes in individuals with COPD. There is a correlation between the presence of hypoxemia and chronic ventilator insufficiency, and the early signs of intimal thickening and medial hypertrophy in the smaller branches of the pulmonary arteries. The pathological changes mentioned are accompanied by pulmonary vasoconstriction caused by alveolar hypoxemia, damage to the pulmonary vascular bed, and alterations in intrinsic pulmonary vasodilator substances. These substances include a decrease in prostacyclin synthase (PGI 2 s), a decrease in endothelial nitric oxide synthase (eNOS), and an increase in endothelin 1 (ET1). These changes contribute to remodelling, increased blood viscosity, and changes in respiratory mechanics. These factors contribute to a notable rise in pulmonary vascular resistance, resulting in pulmonary hypertension. Severe pulmonary hypertension leads to an elevated after load on the right ventricle, causing an increase in its workload. This, in turn, leads to a consistent enlargement of the right ventricle. In individuals diagnosed with COPD, hypoxic vasoconstriction can result in both right ventricular hypertrophy and right ventricular dilatation. Over time, this

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can lead to the development of right heart failure, characterised by systemic congestion and an inability of the right ventricle to meet the increased demand during exercise. Chronic alveolar hypoxia causes vasoconstriction, which in turn raises pulmonary vascular resistance. This can ultimately result in pulmonary hypertension and cor-pulmonale.

Echocardiography is a convenient and noninvasive technique that can be used to assess the impact of COPD on the heart. Echocardiography offers a quick, noninvasive, and reliable way to assess various aspects of cardiac health, including right ventricle function, right ventricular filling pressure, tricuspid regurgitation, left ventricular function, and valvular function.[10] Multiple studies have established a strong correlation between echocardiographically derived estimates of pulmonary arterial pressure and pressures measured by right heart catheter ($r > 0.7$).[11,12]

Thus, a study was conducted to assess the diagnostic value of ECHO findings in COPD patients, specifically focusing on pulmonary and cardiac evaluation. The aim was to identify any cardiac manifestations of COPD and determine their relationship with the severity of the disease. The ultimate goal was to facilitate early intervention, leading to improved quality of life and reduced mortality and morbidity among COPD patients.

2. Material and Methods

A study was conducted on 100 patients with COPD who received treatment at a Tertiary Care Teaching Institute in India **from January 2022 to January 2023.** The COPD cases were identified through a thorough assessment, including clinical history, general physical examination, detailed systemic examination, and necessary investigations. All the patients underwent spirometry testing and were diagnosed and classified based on the GOLD guidelines. Then all the COPD patients underwent resting two-dimensional trans-thoracic Doppler echocardiography. An echocardiography was performed to evaluate the anatomy and function of the pericardium, valvular structures, and both the left and right chambers of the heart, as well as overall cardiac function. The presence of tricuspid regurgitant flow was detected using the colour flow Doppler technique, while the maximum jet velocity was measured using continuous wave Doppler, without the need for intravenous contrast. Estimates of right ventricular systolic pressure were derived using the modified Bernoulli equation, assuming no obstruction in the right ventricular outflow. These estimates were considered equivalent to sPAP. The systolic pressure in the right ventricle, also known as the trans tricuspid pressure gradient (TTPG), can be calculated by adding the peak velocity of tricuspid regurgitation (v) multiplied by 4v2 to the right atrial pressure (RAP).

In the study, pulmonary hypertension was defined as Spap≥30mmHg. The dimensions of the right ventricle were assessed using M-Mode Echo. The presence of right ventricular dilatation or corpulmonale was determined when it exceeded the normal range of 0.9-2.6 cm. Left ventricular function can be evaluated by measuring the ejection fraction (EF), which indicates the amount of blood ejected from the left ventricle during each contraction. The parameters evaluated in ECHO were: Enlargement of the right ventricle, regurgitation of the tricuspid valve, enlargement of the right atrium, high blood pressure in the pulmonary arteries, and evaluation of left ventricular function through the measurement of left ventricular ejection fraction.

Examining the data through statistical analysis

The data was compiled and entered into a spreadsheet computer programme (Microsoft Excel 2007) and then exported to the data editor page of SPSS version 15 (SPSS Inc., Chicago, Illinois, USA). The quantitative variables were reported using either means and standard deviations or median and interquartile range, depending on their distribution. The qualitative

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variables were displayed as counts and percentages. Confidence level and level of significance were set at 95% and 5% respectively for all tests.

3. Results

The study included participants with a wide age range, from 20 to 90 years old, with an average age of 60.10±11.40 years. The majority of patients were male, accounting for 72% of the total. Within the study group, 53 patients (53%) were smokers, indicating that smoking plays a significant role in the development of COPD. Out of the 30 patients, a significant portion (30%) reported being exposed to various environmental factors such as tobacco smoke, occupational dusts, and chemicals.

The study group was divided into different subgroups based on the severity of COPD, following the guidelines set by GOLD. The group was categorised into different stages based on the severity of COPD. These stages include mild COPD, moderate COPD, severe COPD, and very severe COPD. In our study, we observed varying degrees of COPD among the patients. Specifically, 4% had mild COPD, 56% had moderate COPD, 58% had severe COPD, and 10% had very severe COPD.

The study group was further categorised into subgroups based on the length of the illness. The duration of the disease was determined by reviewing the patient's past medical history and any available medical records. A significant number of patients in the study group had a disease duration ranging from 4 to 8 years. The duration of the disease varied between 4 and 20 years, with an average duration of 11.15±5.75 years.

In our study, 24% of cases showed normal echocardiography results. Our study revealed that 70% of the patients exhibited echocardiographic evidence of pulmonary arterial hypertension, based on our analysis of the findings. The prevalence of PAH in ECHO among patients with mild, moderate, severe, and very severe COPD was 0%, 50%, 79.3%, and 100%, respectively. There was a noteworthy correlation found between the severity of COPD and PAH, with a p-value of less than 0.05. Here is Table 1:

Cor-pulmonale, characterised by right ventricular enlargement, was detected in 46% of patients during the ECHO examination. In ECHO, the frequency of right ventricle enlargement in cases of mild, moderate, severe, and very severe COPD was as follows: 0% in mild cases, 28.6% in moderate cases, 48.3% in severe cases, and 100% in very severe cases. As the severity of COPD increased, there was a notable rise in the prevalence of cor-pulmonale and right ventricular enlargement, as shown in Table 2. In patients with COPD, right atrial enlargement was observed in varying degrees of severity. The frequency of this enlargement ranged from mild to very severe, with percentages of 0%, 7.1%, 10.3%, and 60% in each respective category. The prevalence of right atrial enlargement showed a significant correlation with the severity of COPD, as indicated by a p-value of <0.05 (Table 3).

TR was observed in 72% of patients during the ECHO examination. In ECHO, the frequency of tricuspid regurgitation (TR) in different stages of COPD was as follows: 0% in mild, 57.1% in moderate, 79.3% in severe, and 100% in very severe cases. There was a statistically significant positive correlation found between the presence of TR and the severity of COPD, with a p value of <0.05 (Table 4).

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Table 1: Comparison of PAH in echo according to severity of disease

Severity	PAH present		PAH absent		Total
	Number	Percentage (%)	Number	Percentage (%)	
I	0	0	4	100	4
II	14	50	14	50	28
III	46	79.3	12	20.68	58
IV	10	100	0	0	10

Table 2: Comparison of RV size in ECHO according to severity of disease

Severity	PAH present		PAH absent		Total
	Number	Percentage (%)	Number	Percentage (%)	
I	4	100	0	0	4
II	20	71.4	8	28.6	28
III	30	51.7	28	48.3	58
IV	0	100	10	0	10

Table 3: Comparison of RA size in ECHO according to severity of disease

Severity	PAH present		PAH absent		Total
	Number	Percentage (%)	Number	Percentage (%)	
I	4	100	0	0	4
II	26	92.9	2	7.1	28
III	52	89.7	6	10.3	58
IV	4	40	6	60	10

Table 4: Comparison of TR in ECHO according to severity of disease

Severity	PAH present		PAH absent		Total
	Number	Percentage (%)	Number	Percentage (%)	
I	4	100	0	0	4
II	16	57.1	12	42.9	28
III	46	79.3	12	20.7	58
IV	10	100	0	0	10

4. Discussion

COPD is a global concern, causing long-term illness and death.2 Individuals diagnosed with COPD face a significant risk of developing cardiovascular disease, which unfortunately can lead to fatal outcomes. COPD has the potential to impact the pulmonary blood vessels, as well as the right and left sides of the heart.[13-16] A study was conducted to examine the echocardiographic changes observed in patients with COPD and how they relate to the severity of the disease. The clinical course of COPD is often complicated by right ventricular dysfunction and pulmonary blood vessel impairment, which have been found to have an inverse correlation with survival. Patients with COPD experience notable alterations in the pulmonary circulation. There is a correlation between the presence of hypoxemia and chronic

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ventilator insufficiency, and the early signs of intimal thickening and medial hypertrophy in the smaller branches of the pulmonary arteries. These pathological changes are accompanied by pulmonary vasoconstriction caused by alveolar hypoxemia, damage to the pulmonary vascular bed, alterations in intrinsic pulmonary vasodilator substances, reduced eNOS levels, an increase in ET1 resulting in remodelling, increased blood viscosity, and changes in respiratory mechanics. These factors contribute to a notable rise in pulmonary vascular resistance, resulting in the development of pulmonary hypertension. Severe pulmonary hypertension causes an elevation in the after load of the right ventricle, leading to an increase in its workload. This, in turn, leads to a uniform thickening of the right ventricular muscle. In patients with COPD, hypoxic vasoconstriction can cause both right ventricular hypertrophy and right ventricular dilation. This can eventually result in a clinical syndrome of right heart failure, characterised by systemic congestion and an inability of the right ventricle to meet the increased demand during exercise.

The study found that the average age of participants was 60.10±11.40 years. COPD tends to be more prevalent among men and individuals who smoke, typically occurring between the ages of 50 and 70. The study group was divided into subgroups based on the length of time they had the disease. The duration of the disease was determined by considering the patient's past medical history and any available medical records. A significant number of patients in the study group had been living with the disease for a duration of 4-8 years. In a study conducted by Shreshta B et al, it was found that a significant proportion of patients with COPD fell within the age range of 60-75 years. There were comparatively fewer patients in the 45-59 years and 75-89 years age groups.[17]

The majority of patients presented with moderate to severe disease. The study group was divided into different subgroups based on the severity of COPD, following the guidelines set by GOLD. The group was categorized into different levels of COPD severity: mild, moderate, severe, and very severe. The percentages of patients in each category were 4%, 28%, 58%, and 10% respectively. It is worth noting that the study group had a limited number of patients in Stage I, indicating that individuals with COPD tend to seek medical attention at a later stage of the disease. According to a study conducted by Suma et al[18], the study found that out of the total number of patients, 4% had mild COPD, 36% had moderate COPD, and 60% had severe COPD.

Cardiac dysfunction is frequently observed in individuals with COPD, with tricuspid regurgitation and pulmonary arterial hypertension being the prevailing cardiac conditions associated with this respiratory disease. In a study conducted by Tiwari et al in 2015, it was discovered that PAH was detected in 51.6% of individuals with COPD. The prevalence of PAH varied among patients with different levels of severity, with rates of 17%, 52%, 60%, and 78% observed in those with mild, moderate, severe, and very severe COPD, respectively.[19] A study conducted by Maula et al[20] reported similar findings. The exact prevalence of PH in COPD remains uncertain. There is a recorded increase in pulmonary arterial pressure, ranging from 20 to 90%, as measured by right heart catheterization. It has been observed that there is a correlation between the severity of airflow obstruction and the development of pulmonary hypertension.[21,22]

There was a statistically significant difference in the presence of PAH among various groups. Additionally, there is a positive correlation between the severity of COPD and PAH. This means that as the severity of COPD increases, the incidence of PAH also increases. The occurrence of PAH is directly linked to the severity of COPD. Similar findings were reported by Jatav et al[23] and El Wahsh et al[24], indicating that a higher pulmonary artery systolic pressure was observed in 44% and 55.56% of patients, respectively. Furthermore, these

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studies also demonstrated a direct relationship between the severity of COPD and the pulmonary artery systolic pressure.

Out of the total 100 patients included in the study, echocardiography revealed that 46% of them had an enlarged right ventricle (RV). In a study conducted by Jain et al, it was discovered that a significant number of patients with COPD exhibited right ventricular dilatation. The prevalence of this condition varied among different severity levels, with mild, moderate, severe, and very severe patients showing rates of 66.6%, 66.6%, 60%, and 100% respectively.[23] In a study conducted by Tiwari et al, it was discovered that cor plumonale was observed in 23.7% of patients with COPD. The prevalence of this condition varied among patients with different levels of severity, with rates of 12%, 15%, 40%, and 44% in those classified as mild, moderate, severe, and very severe, respectively.[19] There are conflicting findings regarding the impact of COPD on LV function. While some studies suggest that LV function remains normal in individuals with COPD, others indicate the possibility of LV dysfunction.[1,25] Abnormal left ventricular (LV) performance in individuals with chronic obstructive pulmonary disease (COPD) can be attributed to various factors. These include hypoxemia and acidosis, concurrent coronary artery disease, and ventricular interdependence. The right ventricle (RV) and LV share a common septum, and if the RV dilates, it can cause the septum to bulge into the LV. This, in turn, increases LV end-diastolic pressure, reduces venous return, and diminishes LV stroke volume and cardiac output (CO). Additionally, large swings in intrathoracic pressure can also contribute to the abnormal LV performance.[26]

In the group of 100 patients, echocardiography revealed the presence of TR in 72% of them. In a study conducted by Jain et al, it was discovered that tricuspid regurgitation was observed in 60% of patients with COPD. The prevalence of this condition varied among patients with different levels of severity, with rates of 58.3%, 60%, 60%, and 100% in those classified as mild, moderate, severe, and very severe, respectively.[27] In a study conducted by Tiwari et al, it was found that tricuspid regurgitation was present in 74.2% of patients with COPD.[19] Our findings reveal a noteworthy link between tricuspid regurgitation and the severity of COPD, as demonstrated by statistically significant data.

There were certain limitations in the study that affected the accuracy of assessing the prevalence of LVDD. For instance, the use of a two-dimensional Doppler echocardiogram with colour flow, without incorporating tissue Doppler echocardiography, was one such limitation. Unfortunately, right heart catheterization was not an option for obtaining a definitive diagnosis of PH and determining its prevalence.

5. Conclusion

By detecting, closely monitoring, and appropriately treating cardiovascular abnormalities in all patients with COPD, regardless of its severity, it is possible to reduce morbidity and mortality. It is important to consider echocardiography as a key tool in evaluating cardiovascular changes in patients with COPD, regardless of the severity of the condition. There is a clear correlation between the severity of COPD and certain echocardiographic findings. As the severity of COPD increases, there is an increased prevalence of pulmonary arterial hypertension, right ventricular enlargement, right atrial enlargement, and tricuspid regurgitation. It is worth noting that the risk of cardiac dysfunction tends to rise alongside the severity of COPD. In such cases, echocardiography proves to be a valuable tool for assessing the cardiac complications associated with COPD.

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