

Original article:

Echocardiographic evaluation of pulmonary arterial hypertension in chronic obstructive pulmonary disease patient and its co-relation with the severity of disease

**¹Dr. Gaurav Dhandoria , ²Dr. Rohit Dhandoria , ³Dr. Rishi Kumar Sharma , ⁴Dr. Rahul Ahluwalia* ,
⁵Dr. Divax Oza**

¹Senior Resident, Department of Respiratory Medicine , JNU Medical College and Hospital, Jaipur

²Block CMHO

³Professor, Department of Respiratory Medicine , Geetanjali Medical College and Hospital, Udaipur.

⁴Senior Resident, Department of Respiratory Medicine, SMS Medical College and attached Hospitals

⁵Jr. Resident, Department of Respiratory Medicine , Geetanjali Medical College and Hospital, Udaipur.

*Address for Correspondence: Dr. Rahul Ahluwalia, Senior Resident, SMS Medical College and Attached Hospitals E-mail: rahulahluwalia06@gmail.com

ABSTRACT

Background: Chronic obstructive pulmonary disease (COPD) has considerable effects on cardiac functions. Most of the increased mortality associated with COPD is due to cardiac involvement. Echocardiography provides a rapid, non-invasive, portable, and accurate method to evaluate the cardiac changes.

Aims: To assess the cardiac changes secondary to COPD by echocardiography and to find out the correlation between echocardiographic findings and severity of COPD, if there is any.

Materials and Methods: A total 126 of patients of COPD were selected and staged by pulmonary function test (PFT) and evaluated by echocardiography.

Results: On echocardiographic evaluation of COPD, 50% cases had normal echocardiographic parameters. The most common finding was Diastolic dysfunction observed in 77(61.11%) cases followed by tricuspid regurgitation (TR) in 47(37.30%) cases. Pulmonary arterial hypertension (PAH) was observed in 63(50.00%) cases out of 126 COPD patients. out of 126 patients as follow 63(50%), 31(24.6%),18 (14.3%), 14(11.1%) with No PAH, Mild PAH, Moderate PAH, Severe PAH respectively. Mitral stenosis (MS) Mitral regurgitation (MR) & Aortic regurgitation (AR) were detected in 7(5.56%), 18(14.29%) & 9(7.14%) cases respectively. Cardiomegaly & systolic dysfunction was seen in 19(15.08%) and 9(7.14%) cases respectively and only 3(2.38%) showed evidence of myocardial infarction (MI) and 63(50.00%) showed normal study.

Conclusion: Prevalence of cardiovascular diseases is high in COPD in which dysastolic dysfunction and pulmonary hypertension is most commonly found, which is complicating the clinical scenario of COPD patient. 2DEcho is recommended for evaluation and close monitoring of COPD patients to detect cardiovascular system involvement and to manage that accordingly.

Keywords: Chronic obstructive pulmonary disease, echocardiography, pulmonary hypertension

INTRODUCTION

Chronic obstructive pulmonary disease (COPD), defined by GOLD as a preventable and treatable disease with some significant extrapulmonary effects that may contribute to the severity in individual patients. It is characterized by airflow limitation that is not fully reversible. The airflow limitation is usually progressive and associated with an abnormally inflammatory response of the lung to noxious particles or gases.¹ COPD is currently the fourth leading cause of death in the world³, according to world bank data. It is projected to be the 3rd leading cause of death by 2020.² More than 3 million people died of COPD in 2012 accounting for 6% of all deaths globally. There are around three million deaths annually. More than 90% of COPD deaths occur in low and middle income countries. Pulmonary hypertension (PAH) which may develop late in the course of COPD, is the major cardiovascular complication. It is associated with the development of cor-pulmonale and carries a poor prognosis. Cardiovascular disease accounts for approximately 50% of all hospitalization and nearly one third of all deaths, if forced expiratory volume in one second (FEV1) > 50% of predicted.³ In more advanced disease cardiovascular disease account for 20%–25% of all deaths in COPD.⁴ COPD affects pulmonary blood vessels, right ventricle, as well as left ventricle leading to development of pulmonary hypertension, cor pulmonale, right ventricular dysfunction, and left ventricular dysfunction too. Echocardiography provides a rapid, non-invasive portable and accurate method to evaluate the right ventricle function, right ventricular filling pressure, tricuspid regurgitation, left ventricular function and valvular function.⁵ Many studies have confirmed that echocardiographically derived estimates of pulmonary arterial pressure co-relate closely with pressures measured by right heart catheter ($r > 0.7$).^{6,7}

Hence the present study was undertaken with the following aims and objectives:

- 1) To assess the cardiac changes secondary to COPD by echocardiography, and
- 2) To find out the correlation between echocardiographic findings and the severity of COPD using GOLD guidelines.

MATERIALS AND METHODS

One twenty-six patients of COPD confirmed by clinical history, radiology of chest, and pulmonary function test were selected from Chest and T.B. department of Geetanjali Medical College and hospital, Udaipur, Rajasthan. During selection, patients with history of chronic lung disease other than COPD, hypertension, any primary cardiac disease, any systemic disease that can cause pulmonary hypertension, patients with poor echo window, and patients who were unable to perform spirometry were excluded from the study.

All selected patients were subjected to routine investigations, including complete blood count, lipid profile, blood sugar, blood urea, serum creatinine, electrocardiography, and so on, as needed.

All the patients were investigated by spirometry and diagnosed and classified according to GOLD guidelines (post bronchodilator FEV 1 /forced vital capacity (FVC) ratio < 70% predicted), mild (FEV 1 \geq 80% of predicted), moderate (50% \leq FEV 1 < 80% predicted), severe (30% \leq FEV 1 < 50% predicted), and very severe (FEV 1 < 30% predicted), respectively.

All patients were subjected to resting two-dimension transthoracic Doppler echocardiography in the cardiology department of Geetanjali Medical College and hospital and associated hospitals by expert cardiologists. The

machine used was 2 D Echocardiography (Philips HD IE33 (matrix)) with a multifrequency probe with a range of 2–4.3 MHz. Both 2D and M-Mode studies were done.

Echocardiography was reviewed to assess the pericardium, valvular anatomy and function, left and right side chamber size and cardiac function. Tricuspid regurgitant flow was identified by colour flow Doppler technique and the maximum jet velocity was measured by continuous wave Doppler without the use of intravenous contrast. Right ventricular systolic pressure was estimated based on the modified Bernoulli equation and was considered to be equal to the sPAP in the absence of right ventricular outflow obstruction: sPAP (mmHg) = right ventricular systolic pressure = trans-tricuspid pressure gradient (TTPG) + right atrial pressure (RAP), where trans-tricuspid gradient is $4v^2$ (v = peak velocity of tricuspid regurgitation, m/s).^{6,8,9} RAP was empirically estimated as 15 mmHg before 1997. Since 1997, RAP was estimated to be 5, 10, or 15 mmHg based on the variation in the size of inferior vena cava with inspiration as follows: complete collapse, RAP = 5 mmHg; partial collapse, RAP = 10 mmHg; and no collapse, RAP = 15 mmHg.¹⁰

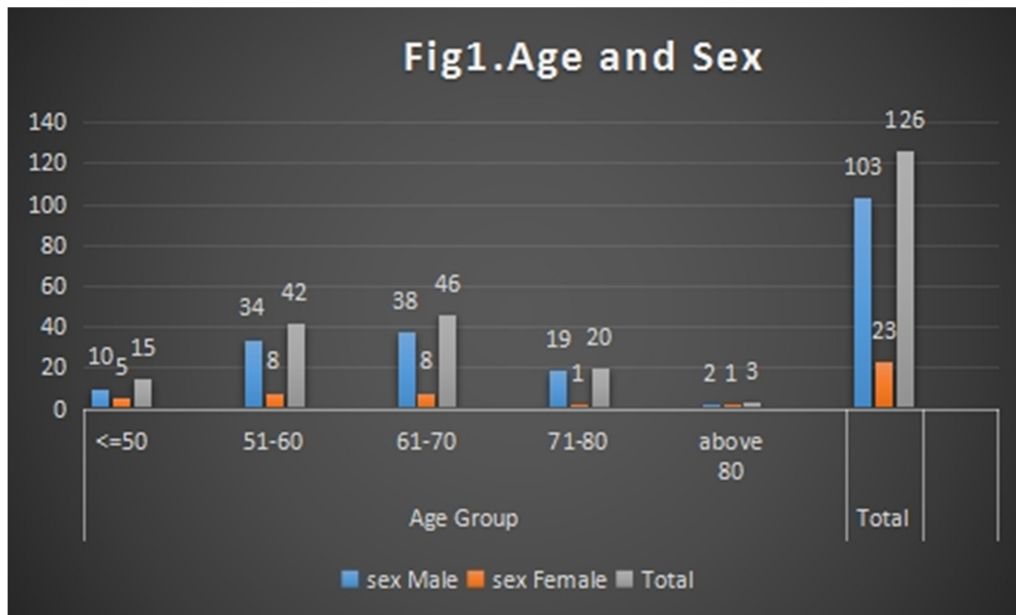
Pulmonary hypertension (PH) was defined in this study as sPAP \geq 30 mmHg.¹¹ This value was chosen according to the definition of pulmonary hypertension. PH was classified into mild, moderate, and severe category as sPAP 30–50, 50–70, >70 mmHg, respectively (using Chemla formula, mean pulmonary arterial pressure (MPAP) = 0.61 PASP + 2 mmHg and putting value of 25–35, 35–45, and >45 mmHg of MPAP for mild, moderate, and severe pulmonary hypertension, respectively).¹²

E/A = diastolic filling of left ventricles usually classified initially on the basis of the peak mitral flow velocity of the early rapid filling wave (E), peak velocity of the late filling wave caused by atrial contraction (A). In normal subjects LV elastic recoil is vigorous because of normal myocardial relaxation, therefore more filling is completed during early diastolic, so left ventricular diastolic dysfunction (LVDD) is said to be present when E/A is <1.3 (age group 45–49 years), <1.2 (age group 50–59 years), <1.0 (age group 60–69 years), and <0.8 (age group \geq 70 years).¹³

RESULT AND OBSERVATIONS

The present study was conducted at department of respiratory medicine, Geetanjali Medical College and Hospital, Udaipur. Total 126 cases of COPD classified as per GOLD 2017 were studied for a period of one year and were subjected for echocardiography to evaluate the cardiac status in COPD patients.

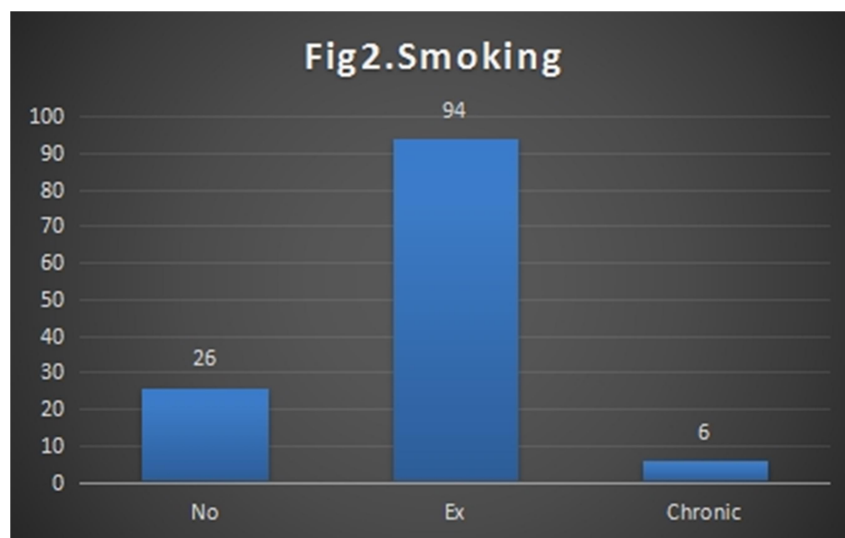
Total 126 patients were examined, out of which 103 were males and 23 were females. There were 5 age groups included in the study. In the age group of <50 years total 15 patients were included, out of which 10 (66.7%) were males and 5 (33.3%) were females



In the age group of 51-60 years total 42 patients were present, out of which 34 (81%) were males and 8 (17.4%) were females.

In the age group of 71-80 years total 20 patients were present out of which 19 (95%) were males and 1 (5%) were females.

In the age group > 80 years total 3 patients were present out of which 2 (66.7%) were males and 1 (33.3%) were females.



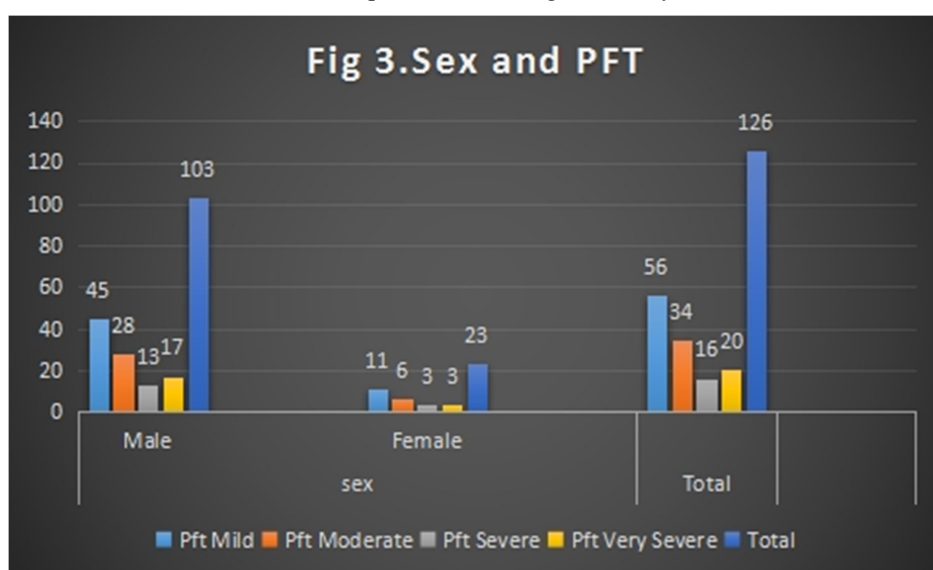
In our enrolled patients, we found that there were 94 patients having history of ex smoking, 6 patients were chronic smoker and 26 having no history smoking.

Table 1: Tobacco chewers

Tobacco	Number	Percent
No	76	60.32
Ex	49	38.89
Chronic	1	0.79
Total	126	100

In 126 enrolled patients, we also found 49 patients having history of ex-tobacco chewing, 1 was chronic chewer and 76 having no history of tobacco chewing.

The distribution of males and female’s patients according to severity of PFT is as follows-

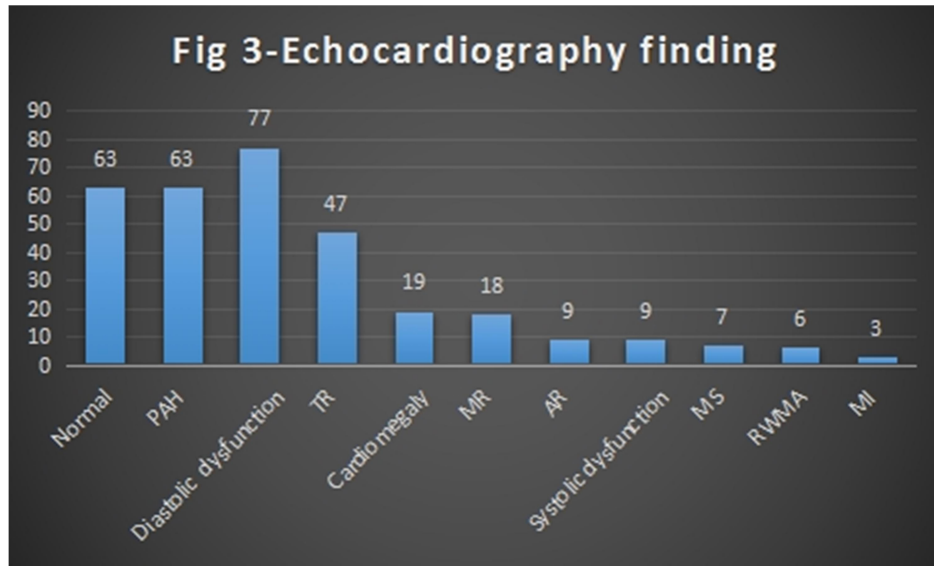


There were 4 categories of PFT (mild, moderate, severe, very severe). In the mild category total 56 patients were present (44.4% of 126) out of which, 45 were males (43.7% of 103) and 11 were females (47.8% of 23).

In the moderate category, total 34 (27% of 126) patients were present out of which 28 were males (27.2% of 103) and six were females (26.1% of 23).

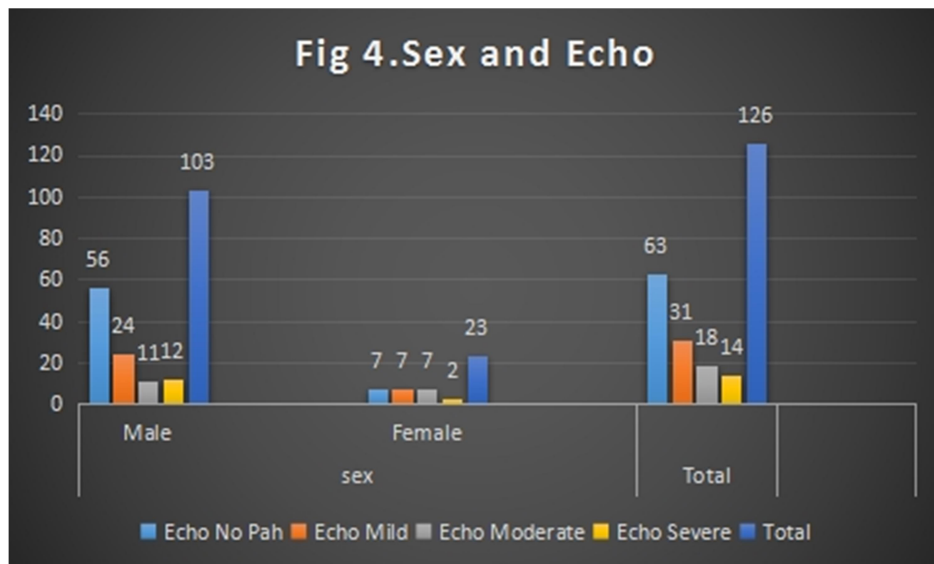
In the severe category total 16 (12.7% of 126) were included out of which 13(12.6% of 103) were males and 3 were females (13% of 23).

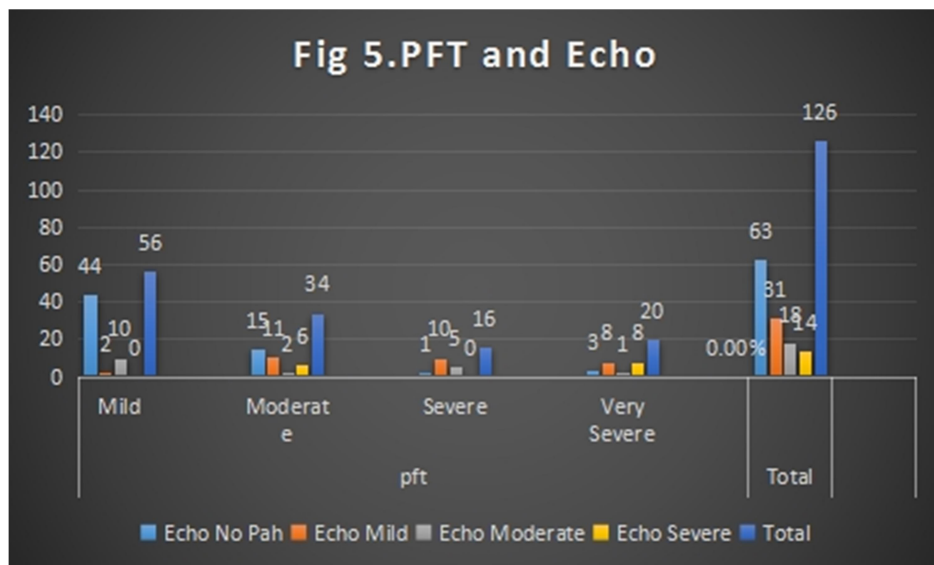
In the very severe category 20 (15.9% of 126) were present, out of which 17 (16.5 of 103) were males and 3 (13% of 23) were females.



Echocardiography finding in COPD cases

On echocardiography, most common finding was Diastolic dysfunction observed in 77(61.11%) cases followed by tricuspid regurgitation (TR) in 47(37.30%) cases. Mitral stenosis (MS) Mitral regurgitation (MR) & Aortic regurgitation (AR) were detected in 7(5.56%), 18(14.29%) & 9(7.14%) cases respectively. Pulmonary arterial hypertension (PAH) was observed in 63(50.00%) cases out of 126 COPD patients. Cardiomegalaly & systolic dysfunction was seen in 19(15.08%) and 9(7.14%) cases respectively and only 3(2.38%) showed evidence of myocardial infarction (MI) and 63(50.00%) showed normal study.





When 126 patients were subjected to PFT following results were found

There were 56, 34, 16, 20 patients with mild, moderate, severe and very severe PFT respectively. Simultaneously when these 126 patients were subjected to 2D Echo following results were found- out of 126 patients as follow 63(50%), 31(24.6%),18 (14.3%), 14(11.1%) with No PAH, Mild PAH, Moderate PAH, Severe PAH respectively. Out of 56 patients with mild PFT 44 (78.6% of 56) had No PAH, 2 (38% of 56) had mild PAH, 10(17.9% of 56) had Moderate PAH, 1(0.1% of 56) had Severe PAH. Out of 34 patients with moderate PFT 15(44.1% of 34) had No PAH, 11(32.4% of 34) had mild PAH, 2(17.6 of 34) had Moderate PAH, 6(17.6%) had severe PAH. Out of 16 patients with severe PFT- 1(6.3% of 16) had No PAH, 10(62.5% of 16) had mild PAH, 5(31.3 of 16) had severe PAH. Out of 20 patients with very severe PFT 3(15% of 20) had No PAH, 8(40% of 20) had mild PAH, 1(5% of 20) had Moderate PAH, 8(40% of 20) had severe PAH.

Table 2: PFT and Echo correlation.

PFT and Echo		Echo			Total
		Mild	Moderate	Severe	
PFT	Mild	2 (16.7%)	10 (83.3%)	0 (0.0%)	12 (100.0%)
	Moderate	11 (57.9%)	2 (10.5%)	6 (31.6%)	19 (100.0%)
	Severe	10 (66.7%)	5 (33.3%)	0 (0.0%)	15 (100.0%)
	Very Severe	8 (47.1%)	1 (5.9%)	8 (47.1%)	17 (100.0%)
Total		31 (49.2%)	18 (28.6%)	14 (22.2%)	63 (100.0%)

There were 63 patients out of 126, who had NO PAH finding on 2D Echo. When remaining 63 patients out of 126 were subjected to both PFT and 2D Echo following results were found. Out of 63 patients 12 patients had mild PFT, 19 had Moderate, 15 had severe, 17 had very severe. Out of 12 with mild PFT when subjected to 2DEcho 2 (16.7%) had mild grade PAH, 10(83.3%) had Moderate PAH, 0(0.0%)had severe grade PAH.

Out of 19 patients with Moderate PFT-11(57.9% of 19) patients had mild PAH, 2 (10.5% of 19) patients had moderate PAH, 6(31.6% of 19) patients had severe PAH.

Out of 15 patients with severe PFT-10(66.7% of 15) had mild PAH, 5(33.3% of 15) had Moderate PAH, 0(0% of 15) had severe PAH.

Out of 17 patients with very severe PFT- 8(47.1%of 17) had mild PAH, 1(5.9% of 17) had Moderate PAH, 8 (47.1% of 17) had severe PAH.

Out of total 63 patients 31 had mild PAH, 18 had Moderate PAH, 14 had severe PAH

DISCUSSION

The cardiac manifestations of COPD are numerous. Impairment of right ventricular dysfunction and pulmonary blood vessels are well known to complicate the clinical course of COPD and co-relate inversely with survival. Significant structural changes occur in the pulmonary circulation in patients with COPD. The presence of hypoxemia and chronic ventilator insufficiency is associated with early evidence of intimal thickening and medial hypertrophy in the smaller branches of the pulmonary arteries. Coupled with these pathological changes are pulmonary vasoconstriction arising from the presence of alveolar hypoxemia, destruction of pulmonary vascular bed, changes in intrinsic pulmonary vasodilator substances (such as decrease in PGI₂ (prostacyclin synthase), decrease in eNOS (endothelial nitric oxide synthase), and increase in ET1 (endothelin1) leads to remodeling,

increase in blood viscosity, and alteration in respiratory mechanics. All these lead to a significant increase in pulmonary vascular resistance, the consequence of which is pulmonary hypertension. Severe PH increases right ventricular after load with a corresponding increase in right ventricular work, which results in uniform hypertrophy of the right ventricle. In patients with COPD, hypoxic vasoconstriction is associated with not only right ventricular hypertrophy but also right ventricular dilation which eventually leads to clinical syndrome of right heart failure with systemic congestion and inability to adapt right ventricular output to the peripheral demand on exercise.

Although the true prevalence of PH in COPD is unknown, an elevation of pulmonary arterial pressure is reported to occur in 20%–90% of patients when measured by right heart catheterization with some evidence that pulmonary hemodynamic worsens with worsening airflow obstruction.¹⁴⁻¹⁹ Two studies have shown an abnormal increase in mean pulmonary arterial pressure (Ppa) in COPD of 0.4–0.6 mmHg per year. These studies illustrate that PH in COPD progresses slowly and occurs in mild as well as severe forms of disease.²⁰⁻²¹

The present study was conducted at Department of respiratory medicine, Geetanjali Medical college and hospital, Udaipur over a period of one year from 24th February 2017. To evaluate cardiovascular status in chronic obstructive pulmonary diseases patients using echocardiography.

The study group comprise of 126 COPD cases which were diagnosed as per GOLD 2017 guidelines, which include combined assessment of COPD (patient symptoms, mMRC dyspnoea score, number of exacerbations) and spirometry grading of severity of COPD based on FEV1/FVC ratio.

In our study group, maximum number of cases 56(44.4%) were found in GOLD grade 1 (mild COPD), 34(27.0%) cases in GOLD grade 2 (moderate COPD), 16 (12.7%)cases were in GOLD grade 3 (severe COPD) and 20(15.9%) cases were in GOLD grade 4 (very severe COPD). Khandelwal et al²² in their study had 4%, 18%, 28% and 15% cases in mild, moderate, severe and very severe grades of COPD while Gupta et al²³ in their study had 45%, 27.5%, 12.5% and 15% cases in mild, moderate, severe and very severe grades of COPD respectively. In our study group most number of cases were of mild COPD because they were taking regular medication for it, and their compliance was good.

In this study population using the combined assessment test for COPD, patients were categorised into group A (low risk – low symptoms), group B (low risk – more symptoms), group C (high risk- less symptoms) or group D (high risk- more symptoms). 55.55% patients belonged to group A, 15.87% belonged to group B and 28.57% belonged to group D. No patients were found to be in group C. These results are in contrast with study done by Haughney et al²⁴ where 36.1% patients fell into category A, 19.01% fell into category B, 19.06% fell into category C and 25.3% fell into category D. In a study done by Meilan et al²⁵ the distribution of symptoms into various categories were as follows 1507 (33.6%) patients in category A, 919 (20.5%) in category B, 355 (7.09%) in category C and 1703 (38%) in category D. As compared to both above mentioned study, no patients were seen in category C in our study. This may be due to small sample size in our study (n=126) as compared to Haugney et al (n=6283) and Meilan et al (n=4484).

In our study most patients of both the sexes were in mild COPD group where males were 45 and females were 11 followed by moderate group of COPD where males were 28 and females were 6, followed by very severe where males were 17 and females were 3, followed by severe COPD group where males were 13 and females were 3

respectively. These results are similar to the study done by Gupta et al²³ in which 45% patients (18 patients out of total 40 patients) were in mild group.

In our study population males 103(81.75%) outnumbered females 23(18.25%) in all age groups which is almost similar in comparison to study done by Jain et al²⁶ where males were 70.2% and females were 29.8%. Similar results were observed in the Canadian community health survey and a study done by Antonio et al in which males were 79.2% and females were 20.3%.

In our study most patients belonged to age group 50 year to 80 year of age (94%) with predominance in 61-70 year of age. This is also supported by results of KAISER Permanente medical care program.²⁷

Most of the patients were smokers (74.60%) in our study. Echocardiographic assessment was done in our study group as it is a reliable non-invasive tool to evaluate cardiac status even in COPD patients as stated by Jaerpe et al²⁸, Whig et al²⁸, Higham et al²⁹. In our study most common finding was diastolic dysfunction in 77(61.11%), PAH in 63(50%), TR in 47(37.30%) and systolic dysfunction in 9(7.14%). Gupta et al found TR in 27(67.5%), diastolic dysfunction in 19(47.5%), PAH in 17(42.5%) and systolic dysfunction in 3(7.5%) cases. In a study done by Shrestha et al³⁰ 56.3% patients had features of chronic Cor-pulmonale. Mild PAH was seen in 41.9% of cases, moderate in 17.6% of cases and severe in 3.7% of cases. Diastolic dysfunction was seen in 38.7% of cases. In study done by Jataw et al³¹ PAH was found in 44% of cases. In our study PAH was found in 50% of cases and diastolic dysfunction in 61.11% of cases. George funk et al³² stated that diastolic dysfunction may be present in COPD patients with normal PAP and increase with right ventricular afterload which might be another cause of increased diastolic dysfunction.

Prevalence of PAH in stable COPD varies from 20 to 90% depending on the definition of PAH, severity of COPD and the method of measuring the pulmonary artery pressure, as described by Shujaat et al³³. In a study of 120 patients done by Scharf et al³⁴, 90.8% patients had end expiratory pulmonary artery mean pressure > 20mmHg. Pulmonary hypertension (PAP mean >25 mmHg) was present in 50.2% of patients in a study done by Thabut et al³⁵. It was moderate (PAP 35-45 mmHg) in 9.8% of cases and severe (PAP >45 mmHg) in 3.7% of cases. Incidence of PAH was 30.4% in a study done by Cuttica et al³⁶ in 4930 patients. In our study PAH was present in 63 patients (50%) which is range of 20 to 91% (Shujaat et al). Incidence of PAH was 42.5% in a study done by Gupta et al which is comparable to the result of study.

In our study systolic dysfunction was present in 9(7.14%). In a study done by Gupta et al, systolic dysfunction was found to be present in 7.5%.

Mac Allister et al, in their study of 242 patients of acute exacerbation of COPD, reported that 20 patients (8.3%) had chest pain and/or serial ECG changes fulfilling the 2007 universal definition of myocardial infarction. In our study MI was present in 3 cases (2.38%).³⁷

CONCLUSION

In this study, we concluded that prevalence of cardiovascular diseases is high in COPD in which dysastolic dysfunction and pulmonary hypertension is most commonly found, which is complicating the clinical scenario of COPD patient. Hence our study suggested that 2DEcho is recommended for evaluation and close monitoring of COPD patients to detect cardiovascular system involvement and to manage that accordingly.

REFERENCES

1. Rabe KF. Global Initiative for Chronic Obstructive Lung Disease. Global strategy for the diagnosis, management, and prevention of chronic obstructive pulmonary disease. GOLD executive summary. *Am J Respir Crit Care Med* 2007;176:532-55.
2. Murray CJ, Lopez AD. Evidence-based health policy--lessons from the Global Burden of Disease Study. *Science* 1996;274:740-3.
3. Anthonisen N, Connett JE, Kiley JP, Altose MD, Bailey WC. Effects of smoking intervention and the use of an inhaled anticholinergic bronchodilator on the rate of decline of FEV1. *JAMA* 1994;272:1497-1505.
4. Sin DD, Anthonisen NR, Soriano JB, Agusti AG. Mortality in COPD: Role of comorbidities. *Eur Respir J* 2006;28:1245-57.
5. Daniels LB, Krummen DE, Blanchard DG. Echocardiography in pulmonary vascular disease. *Cardiol Clin* 2004;22:383-99.
6. Yock PG, Popp RL. Noninvasive estimation of right ventricular systolic pressure by Doppler ultrasound in patients with tricuspid regurgitation. *Circulation* 1984;70:657-62.
7. Tamarin R, Torbicki A, Marchandise B, Laaban JP, Morpurgo M. Doppler echocardiographic evaluation of pulmonary artery pressure in chronic patients: Echocardiographic evaluation of heart in COPD patient. *Eur Heart J* 1991;12:103-11.
8. Currie PJ, Seward JB, Chan KL, Fyfe DA, Hagler DJ, Mair DD, et al. Continuous wave Doppler estimation of right ventricular pressure: A simultaneous Doppler-catheterization study in 127 patients. *J Am Coll Cardiol* 1985;6:750-6.
9. Chan KL, Currie PJ, Seward JB, Hagler DJ, Mair DD, Tajik AJ. Comparison of three Doppler ultrasound methods in the prediction of pulmonary artery pressure. *J Am Coll Cardiol* 1987;9:549-54.
10. Bredikis AJ, Liebson PR. The echocardiogram in COPD: Estimating right heart pressures. *J Respir Dis* 1998;19:191-8.
11. Rappaport E. Cor pulmonale. In, Murray JJ, Nadel JA, Mason RM, Boushey H (eds). *Textbook of respiratory medicine*, 4th Edition. Philadelphia, W.B. Saunders 2000;1631-48.
12. Chemla D, Castelain V, Humbert M, Simonneau JLHG, Lecarpentier Y, Hervé P. New formula for predicting mean pulmonary artery pressure using systolic pulmonary artery pressure. *Chest* 2004;126:1313-7.
13. Braunwald's Heart Disease. 8th Edition. By Libby P, Bonow RO, Zipes DP, Mann DL. Philadelphia: Saunders 2008. p. 251.
14. Weitzenblum E, Hirth C, Ducolone A, Mirhom R, Rasaholinjanahary J, Ehrhart M. Prognostic value of pulmonary artery pressure In chronic COPD. *Thorax* 1981;36:752-8.
15. Weitzenblum E, Sautegeau A, Ehrhart M, Mammosser M, Hirth C, Roegel E. Long term course of pulmonary artery pressure In chronic COPD. *Am Rev Respir Dis* 1984;130:993-8.
16. Burrows B, Kettel LJ, Niden AH, Rabinowitz M, Diener CF. Patterns of cardiovascular dysfunction in COPD. *N Engl J Med* 1972;286:912-8.

17. Fishman AP. State of the art: Chronic cor pulmonale. *Am Rev Respir Dis* 1976;114:775-94.
18. Pietra G. Pathology of the pulmonary vasculature and heart. In; Cherniack N, editor. COPD. Philadelphia: WB Saunders; 1996. p. 21-6.
19. Thabut G, Dauriat G, Stern JB, Logeart D, Lévy A, Marrash-Chahla R, et al. Pulmonary haemodynamics in advanced COPD candidates for lung volume reduction surgery or lung transplantation. *Chest* 2005;127:1531-6.
20. Weitzenblum E, Sautegau A, Ehrhart M, Mammosser M, Pelletier A. Long-term oxygen therapy can reverse the progression of pulmonary hypertension in patients with chronic obstructive pulmonary disease. *Am Rev Respir Dis* 1985;131:493-8.
21. Kessler R, Faller M, Weitzenblum E, Chaouat A, Aykut A, Ducolone A, et al. "Natural history" of pulmonary hypertension in a series of 131 patients with chronic obstructive pulmonary disease. *Am J Respir Crit Care Med* 2001;164:219-24.
22. Khandelwal MK, Maheshwari VD, Garg S, Kumar K, Gupta R, Khandelwal S. Six-minute walk distance: Correlation with spirometric and clinical parameters in chronic obstructive pulmonary disease. *Int J Healthcare Biomed Res* 2013;1:217-6.
23. Gupta NK, Agrawal RK, Srivastav AB, Ved ML. Echocardiographic evaluation of heart in chronic obstructive pulmonary disease patient and its co-relation with the severity of disease. *Lung India: official organ of Indian Chest Society* 2011;28:105.
24. Haughney J, Gruffydd-Jones K, Roberts J, Lee AJ, Hardwell A, McGarvey L. The distribution of COPD in UK general practice using the new GOLD classification. *Eurp Resp J* 2014;43:993-1002.
25. Han MK, Muellerova H, Curran-Everett D, Dransfield MT, Washko GR, Regan EA, et al. GOLD 2011 disease severity classification in COPDGene: a prospective cohort study. *The Lancet Resp Med* 2013;1:43-50.
26. Jain NK, Thakkar MS, Jain N, Rohan KA, Sharma M. Chronic obstructive pulmonary disease: Does gender really matter? *Lung India: official organ of Indian Chest Society*. 2011;28(4):258.
27. Sidney S, Sorel M, Quesenberry 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.
28. Skjaerpe T, Hatle L. Diagnosis and assessment of tricuspid regurgitation with Doppler ultrasound. In *Echocardiology* 1981 (pp. 299-304). Springer, Dordrecht.
29. Higham MA, Dawson D, Joshi J, Nihoyannopoulos P, Morrell NW. Utility of echocardiography in assessment of pulmonary hypertension secondary to COPD. *Eurp Resp J* 2001;17:350-5.
30. Shrestha B, Dhungel S, Chokhani R. Echocardiography based cardiac evaluation in the patients suffering from chronic obstructive pulmonary disease. *Nepal Med Coll J* 2009;11:14-8.
31. Jatav VS, Meena SR, Jelia S, Jain P, Ajmera D, Agarwal V, et al. Echocardiographic findings in chronic obstructive pulmonary disease and correlation of right ventricular dysfunction with disease severity. *Int J Adv Med* 2017;4:476-80.

32. Funk GC, Lang I, Schenk P, Valipour A, Hartl S, Burghuber OC. Left ventricular diastolic dysfunction in patients with COPD in the presence and absence of elevated pulmonary arterial pressure. *Chest* 2008;133:1354-9.
33. Shujaat A, Bajwa AA, Cury JD. Pulmonary hypertension secondary to COPD. *Pulm Med* 2012;2012.
34. Scharf SM, Iqbal M, Keller C, Criner G, Lee S, Fessler HE. Hemodynamic characterization of patients with severe emphysema. *Am J Respir Crit Care Med* 2002;;166:314-22.
35. Thabut G, Dauriat G, Stern JB, Logeart D, Lévy A, Marrash-Chahla R, et al. Pulmonary hemodynamics in advanced COPD candidates for lung volume reduction surgery or lung transplantation. *Chest* 2005;127:1531-6.
36. Cuttica MJ, Kalhan R, Shlobin OA, Ahmad S, Gladwin M, Machado RF, et al. Categorization and impact of pulmonary hypertension in patients with advanced COPD. *Resp Med* 2010;104:1877-82.
37. McGarvey LP, John M, Anderson JA, Zvarich MT, Wise RA. Ascertainment of Cause-Specific Mortality in COPD--Operations of the TORCH Clinical Endpoint Committee. *Thorax* 2007 Feb 20.

Author Declaration: Source of support: Nil, Conflict of interest: Nil

Was informed consent obtained from the subjects involved in the study? YES

For any images presented appropriate consent has been obtained from the subjects: NA

Plagiarism Checked: Urkund Software

Author work published under a Creative Commons Attribution 4.0 International License

DOI: 10.36848/IJBAMR/2020/29215.55910

