A Profile of Cardiac Manifestations of Chronic Obstructive Pulmonary Disease in a Tertiary Care Hospital in Guwahati, Assam

Prosenjit Roy[1], Angelia Lalsiemlawm Khawbung[2], Ubedul Islam[3], Swaroop Kumar Baruah[4]

[1, 2] Department of Medicine, Fakhruddin Ali Ahmed Medical College and Hospital, Barpeta, Assam, India.
[3, 4]Department of Medicine, Gauhati Medical College and Hospital, Guwahati, Assam, India.

ABSTRACT

BACKGROUND

Chronic obstructive pulmonary disease (COPD) is a global issue with smoking being the most important risk factor. Co-existence of both COPD and cardiovascular diseases is very common and has diagnostic, therapeutic and prognostic implications. The cardiac manifestations of chronic obstructive pulmonary disease are numerous. COPD affects pulmonary blood vessels, right ventricle as well as left ventricle leading to the development of pulmonary hypertension, cor pulmonale, right ventricular dysfunction and left ventricular dysfunction. Because cardiac abnormalities clearly contribute to overall morbidity of COPD, an understanding of their role and potential for treatment is vital. The purpose of this study was to evaluate various cardiac manifestations in chronic obstructive pulmonary disease patients and to observe correlation with its severity.

METHODS

This hospital based observational study was done in Gauhati Medical College and Hospital attending in-patient department (IPD) and out-patient department (OPD) of Department of General Medicine from 1st July 2018 to 30th June 2019. A total of 140 patients were included in this study.

RESULTS

Majority of the patients were in the age group of 60 - 70 years. Cardiovascular manifestations were most commonly observed in very severe stage of COPD (GOLD IV). Overall, 91 patients had ECG changes. The most common ECG findings were P pulmonale and right ventricular hypertrophy (RVH). Pulmonary arterial hypertension (PAH) and tricuspid regurgitation (TR) were common echocardiography findings.

CONCLUSIONS

Cardiac manifestations were more prevalent in COPD GOLD III and IV stages and therefore with increasing severity of COPD, occurrence and severity of cardiac complications becomes more prevalent. ECG and echocardiography are essential investigational tools for diagnosing COPD patients with cardiac complications and assessing their severity. However, a prospective study including a larger sample size is required to arrive at a definite conclusion.

KEYWORDS

COPD, Cardiac manifestations, ECG, Echocardiography, PAH, RVH

Corresponding Author:
Dr. Angelia Lalsiemlawm Khawbung,
New Girls Hostel,
Opp. Residents Quarter,
Barpeta-781301, Assam, India.
E-mail: angekhawbung@gmail.com

DOI: 10.18410/jebmh/2021/592

How to Cite This Article:
Roy P, Khawbung AL, Islam U, et al. A profile of cardiac manifestations of chronic obstructive pulmonary disease in a tertiary care hospital in Guwahati, Assam. J Evid Based Med Healthc 2021;8 (35):3257-3263. DOI: 10.18410/jebmh/2021/592

Submission 17-06-2021,
Peer Review 27-06-2021,
Acceptance 09-08-2021,
Published 30-08-2021.

BACKGROUND

Chronic obstructive pulmonary disease is a global issue with smoking being the most important risk factor. By 2020, it is the third most leading cause of mortality and fifth leading cause of morbidity in the world.[1]

There is a crude estimate of about 30 million people in India suffering from COPD, and the death rate is among the highest in the world. Data suggests that about 5, 56,000 i.e. (> 20 %) of total 2,748,000 COPD patients die in India annually. However, it is to recognize that prevalence estimates in COPD are not totally accurate. The reported estimates have ranged from 2 to 22 % in men and from 1.2 to 19 % in women. The recent Indian study of asthma, respiratory symptoms and chronic bronchitis (INSEARCH) study of 85,105 men and 84,470 women from 12 urban and 11 rural sites reported the prevalence of chronic bronchitis to be 3.49 % (4.29 % in males and 2.7 % in females) in adults > 35 years.[2]

The cardiac manifestations of chronic obstructive pulmonary disease are numerous. COPD affects pulmonary blood vessels, right ventricle as well as left ventricle leading to the development of pulmonary hypertension, cor pulmonale, right ventricular dysfunction and left ventricular dysfunction. Ischemic heart disease is one of the main causes of mortality in COPD. Co-existence of both diseases is very common and has diagnostic, therapeutic and prognostic implications.[3] Reduced ratio of forced expiratory volume/forced vital capacity (FEV1/FVC) is also an independent risk factor for coronary events, increasing the risk by 30 %. With every 10 % decrease in FEV1, mortality increases by 14 % and an increase in cardiovascular mortality by 28 %. Because cardiac abnormalities clearly contribute to overall morbidity of COPD, an understanding of their role and potential for treatment is vital.[4] There is scarcity of data in this segment of association of cardio-pulmonary disease and hence this study was done to confirm the various cardiac manifestations in COPD patients and to determine the correlation of cardiovascular complications with its severity.

Objectives

To evaluate various cardiac manifestations in chronic obstructive pulmonary disease patients and to observe correlation with its severity.

METHODS

This hospital based observational study was conducted in 140 patients of chronic obstructive pulmonary disease admitted to Department of General Medicine, Gauhati Medical College and Hospital from 1st July 2018 to 30th June, 2019. After taking ethical committee clearance and informed consent, the enrolled COPD patients were diagnosed on the basis of history, clinical examination with special reference to respiratory and cardiovascular system and relevant investigations which included ECG, chest-X ray, echocardiography. Patients fulfilling the inclusion and exclusion criteria were taken into account for the study. Spirometry was also done in all patients including pre and post bronchodilator reading and was categorized according to GOLD criteria of COPD. Data was recorded into a preformed and pretested proforma.

Inclusion Criteria

1. Patients diagnosed as chronic obstructive pulmonary disease.
2. Age > 18 years.

Exclusion Criteria

1. Pneumonia.
2. Tuberculosis.
3. Bronchial asthma.
4. Acute exacerbation of COPD.
5. Interstitial lung disease.
6. Carcinoma lung.
7. Known cardiac diseases.
8. Chronic liver disease.
9. Chronic kidney disease.
10. Active infection.

Statistical Analysis

Statistical analysis was done by MS Excel 07 and GRAPHPAD INSTAT software. Categorical variables were expressed as absolute and relative frequency.

RESULTS

In this study, out of 140 patients, 30 cases were in the age group of > 70 years, 52 cases were in the age group of 60 - 70 years, 43 cases in 50 - 60 years and 15 cases in 40 - 50 years age group. Mean age of the study population was 61.9 years with a standard deviation of 9.25 years. There was no case found below the age of 30 years.

Age in Years	Number of Patients	Percentage (%)	Mean Age (Years) ± SD
40 - 50	15	10.7	61.9 ± 9.25
50 - 60	43	30.7	
60 - 70	52	37.14	
>70	30	21.42	

Table 1. Age Distribution

Out of 140 diagnosed COPD patients, 101 (72.14 %) and 39 (27.86 %) were males and females respectively.

Sex	No. of Patients	Percentage (%)
Male	101	72.14
Female	39	27.86
Total	**140**	**100**

Table 2. Sex Distribution

In the present study, majority of the patients were in GOLD stage III. Out of 140 patients, 12 patients (8.57 %) were in GOLD stage I, 42 patients (30 %) in GOLD stage II, 59 patients (42.14 %) in GOLD III and 27 patients (19.29 %) in GOLD stage IV.

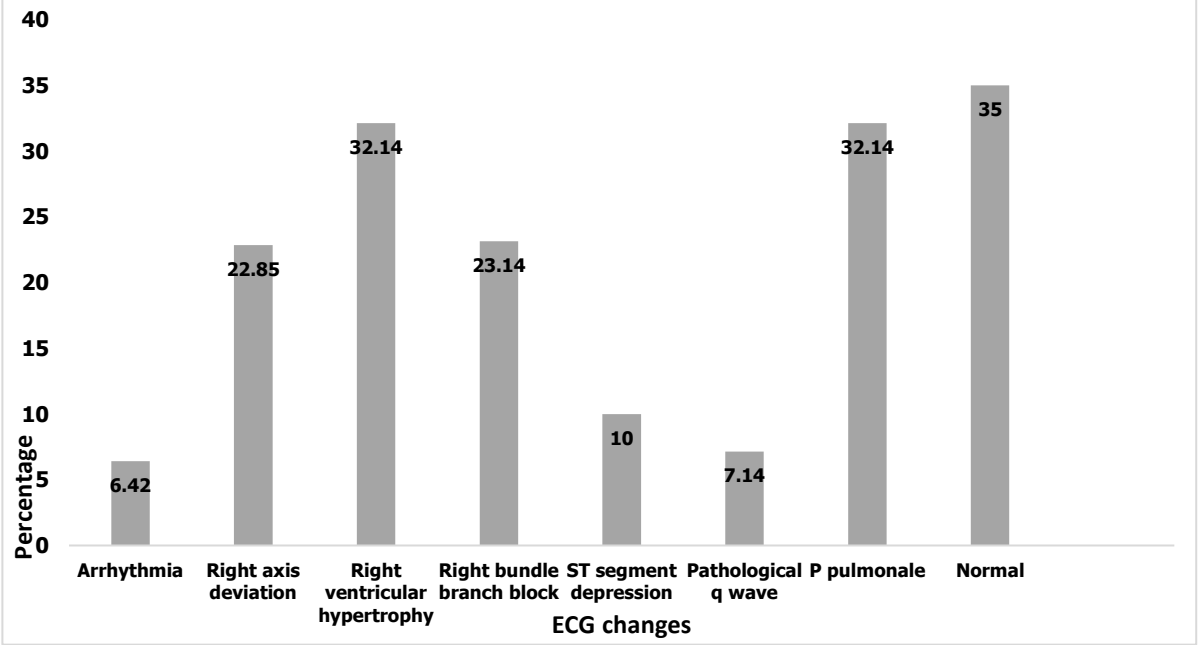

Figure 1. ECG Changes in COPD Patients

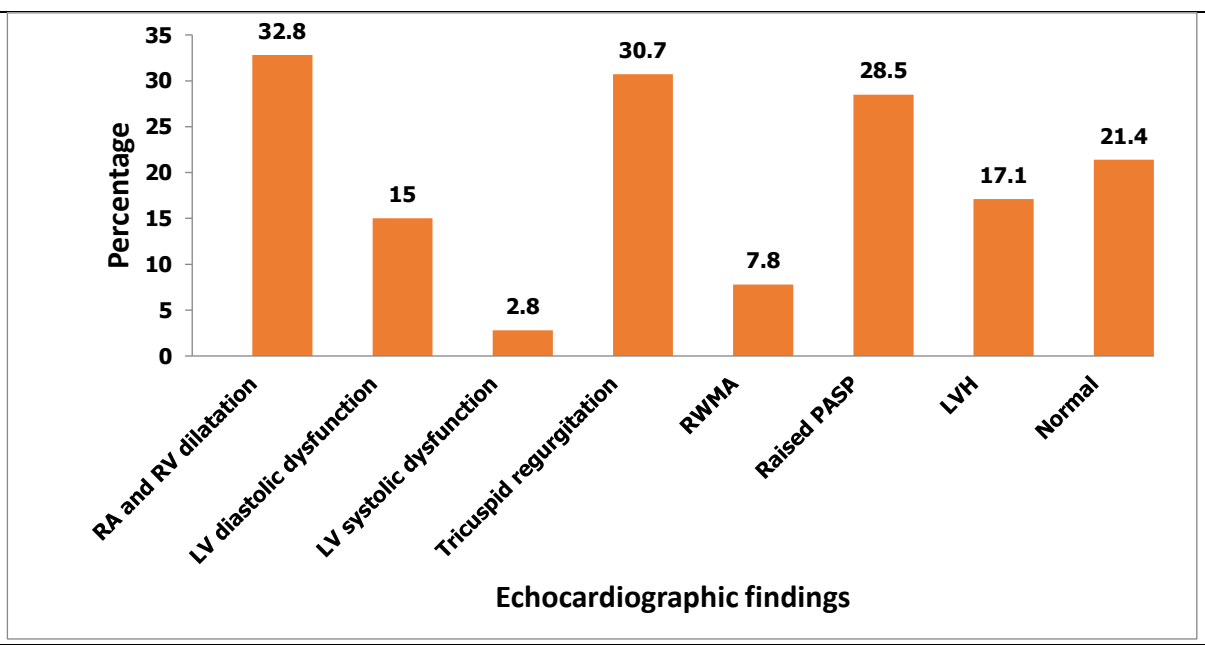

Figure 2. Echocardiographic Findings in COPD Patients

Gold Stage	No. of Patients	Percentage (%)
I	12	8.57
II	42	30
III	59	42.14
IV	27	19.29

Table 3. Distribution of Patients According to Gold Stage

ECG Findings in COPD

Overall, 91 patients had ECG changes. Arrhythmia was seen in 9 (6.42 %) of the study population among which 5 (3.57 %), 2 (1.42 %) and 2 (1.42 %) had atrial fibrillation (AF), multi atrial tachycardia (MAT) and paroxysmal supra-ventricular tachycardia (PSVT) respectively. The changes in right axis deviation (RAD) were seen in 32 (22.85 %) patients of which 13 (40.63 %) and 19 (59.38 %) was seen in severe and very severe COPD cases. The changes of right ventricular hypertrophy (RVH) were observed in 45 (32.14 %) patients. The changes of right bundle branch block (RBBB) were seen in 33 (23.57 %) patients. The changes of ST segment depression were seen in 14 (10 %) patients of which 1 (7.14 %), 1 (7.14 %), 5 (35.7 %) and 7 (50 %) were seen in mild, moderate, severe and very severe COPD patients respectively. The changes of pathological q wave were observed in 10 (7.14 %) patients of which 4 (40 %) and 5 (50 %) were seen in severe and very severe COPD respectively. The presence of P pulmonale was observed in 45 (32.14 %) patients of which 6 (13.3 %), 20 (44.4 %) and 19 (42.2 %) were seen in moderate, severe and very severe COPD patients respectively. 49 (35 %) patients had normal ECG findings.

Echocardiography Findings in COPD

The changes of right atrium and right ventricle dilatation were seen in 46 (32.8 %) patients of which 6 (13.04 %), 25

(54.3 %) and 15 (32.6 %) were seen in moderate, severe and very severe GOLD COPD stages respectively. Left ventricular dysfunction (LVD) was found in 25 (17.8 %) patients of whom 10 (40 %) and 15 (60 %) were seen in severe and very severe GOLD COPD stages respectively. Among those patients with left ventricular dysfunction, 15 % and 2.8 % had diastolic and systolic dysfunction respectively. Tricuspid regurgitation was seen in 43 (30.7 %) patients of which 2 (4.6 %), 7 (16.2 %), 16 (37.2 %) and 18 (41.8 %) was seen in mild, moderate, severe and very severe GOLD COPD stage respectively. The presence of regional wall motion abnormality was seen in 11 (7.8 %) patients of which 4 (36.3 %) and 7 (63.6 %) were seen in severe and very severe GOLD COPD stage respectively. Pulmonary arterial hypertension was found in 40 (28.5 %) patients. Left ventricular hypertrophy was seen among 24 (17.1 %) patients of which 2 (8.3 %), 8 (33.3 %), 14 (58.3 %) was moderate, severe and very severe COPD respectively. Out of 140 patients, 30 (21.4 %) patients had normal echocardiographic findings.

DISCUSSION

Mean age in the study population was 61.9 years with a standard deviation of 9.25 years. The majority of study population was in the age group of 60 to 70 years (37.14 %). This age distribution is comparable to a study conducted by Kolsum U et al. (2009) who reported a mean age of 63.78 ± 8.32 years.[5] Similarly, Castagna O et al. (2008) and Blum A et al. (2011) reported a mean age of 67.63 years and 69.86 years respectively.[6,7] In Pecci R et al. (2012) mean age was 70.26 years.[8] Mahender V et al. (2017) found higher number of COPD patients in age group of 61 - 70 years (38%) followed by 51 - 60 years (24 %).[9]

In the present study, out of 140 patients, 101 (72.14 %) were males and 39 (27.86 %) were females with a male to female ratio of 2.5 : 1 showing male preponderance.This is similar to studies conducted by Serapinas D et al. (2011) who reported 78.1 % males.[10] Similarly, Oliveira JCM et al. (2013) and Jain NK et al. (2011) reported 79 % and 70.2 % males respectively.[11,12] Similar results were documented by Folchini F et al. (2011) with male population being 68.88 % in the study group.[13] However, certain studies like those of Soriano JB et al. (2005) and Sinha B et al. (2017) reported 51 % and 46 % female patients respectively in their study.[14,15] The difference in their study results might be due to the different smoking behaviour of the study population and also due to the difference in the sample size, both the studies being done in 2699 and 1200 patients respectively.

ECG Findings

Among the 140 patients in our study, 91 patients had ECG changes. However, each patient had more than one existing ECG changes.

Arrhythmia was seen in 9 (6.42 %) patients of which 5 (3.57 %), 2 (1.42 %) and 2 (1.42 %) had atrial fibrillation, multi atrial tachycardia and paroxysmal supraventricular tachycardia respectively. Our study was in accordance with the results obtained by Curkendall et al. (2006) and Cazzola et al. (2010) where arrhythmia was seen in 21.1 % and 15.9 % patients respectively.[16,17] In a study conducted by Mapel et al. (2005) atrial fibrillation was 14.3 %.[18] The prevalence of arrhythmia in a study by Hudson et al. (1973) was 47 % which was higher than the percentage obtained in our study.[19] This could be due to the fact that they involved only patients with severe stages of COPD, but our study involved all stages of COPD.

The changes of right axis deviation were seen in 32 (22.85 %) patients of which 13 (40.63 %) and 19 (59.38 %) were seen in severe and very severe GOLD COPD stage respectively. Right axis deviation accounted for 13.2 % of patients in a study conducted by Singh I I et al. (2013).[20] A study by D Holtzman et al. (2011) reported high prevalence of right axis deviation in ECG in COPD patients, increasing with severity of the disease.[21]

RVH was seen in 45 (32.14 %) patients of whom 7 (15.5 %), 15 (33.3%) and 23 (51.1 %) are seen in moderate, severe and very severe GOLD COPD stage respectively. Holtzmann D et al. (2011) found that 29 % patients had RVH and this study agreed with our result.[21] However, only 3.7% of patients had RVH in a study reported by Singh I I et al. (2013)[20] probably due to a smaller number of patients and other diseases were taken into account.

RBBB was seen in 23.5 % of patients in our study. Our result was similar to the study done by Holtzman D et al. (2011) where RBBB was found in 29 % patients.[21] However, studies conducted by McAllister DA et al. (2012)[22] and Singh I I et al. (2013)[20] showed lower percentages of 6 % and 9.4 % respectively which is in contrast to our study.

The change of ST segment depression was seen in 14 (10 %) patients. Our result was similar to the results obtained by Singh I I et al. (2013), McAllister DA et al. (2012) and Warnier M J et al. (2013) where the percentages of patients were7.5 %,9 % and 10 % respectively.[20,22,23] In a study by Kinagi et al. (2014), 18% had ST segment depression which disagreed with this study.[24]

The changes of pathological q wave were observed in 10 (7.14 %) patients. In a study by Warnier M J et al. (2013), pathological q wave was found in 14 % of patients which is in consistent with the present study.[23]

The presence of P pulmonale was observed in 45 (32.14 %) patients of which 6 (13.3 %), 20 (44.4 %) and 19 (42.2 %) are seen in GOLD COPD stage II, III and IV respectively. In accordance with our results, R C Scott et al. (1955) and Pinto et al. (1960) had done a study on COPD patients showing the incidence of p pulmonale to be 32.7 %.[25,26] In an Indian study by Agarwal SR et al. (2015) the incidence of p pulmonale was found to be 35.7 %.[27] However, study conducted by Alexander V et al. (2015) showed variable percentage of P pulmonale (20 %) probably due to variation in severity of COPD.[28]

Echocardiography Findings

The changes of right atrium and right ventricle dilatation were seen in 46 (32.8 %) patients of which 6 (13.04 %), 25 (54.3 %) and 15 (32.6 %) were seen in moderate, severe and very severe GOLD COPD stages respectively. Similar

results were reported by Feixa X et al. (2013) where 29.9 % showed chamber dilatation.[29] There was discrepancy in the results obtained by Mohammed YM et al. (2019)[30] that showed 18 % of patients had chamber dilatation which could be due to the fact that less number of patients and mild stages of COPD were taken into account.

Left ventricular dysfunction was found in 25 (17.8 %) patients of whom 10 (40 %) and 15 (60 %) were seen in severe and very severe GOLD COPD stages respectively. Among those patients with left ventricular dysfunction, 15 % and 2.8 % had diastolic and systolic dysfunction respectively. Study conducted by Mascarenhas J et al. (2008) and Franssen FM et al. (2014) accounted for 20 % of COPD patients with left ventricular diastolic dysfunction (LVDD) which is similar with our study.[31,32] The prevalence of left ventricular diastolic dysfunction was found to be 25 % in a study conducted by Mohammed YM et al. (2019) which is in accordance with our study.[30] However, our result was in contrast to Gupta NK et al. (2011) who showed a higher frequency of left ventricular diastolic dysfunction in patients with COPD (47.5 %).[33] Another study by López-Sańchez et al. (2013) showed a higher incidence of left ventricular diastolic dysfunction (90 %).[34] The difference in the frequency of LVDD in patients with COPD between this study and the previous studies might be due to different age group, absence of comorbidites, etc. In this study only 2.8 % of patients had left ventricular systolic dysfunction (LVSD) which was similar to the result reported by Gupta NK et al. (2011) (7.5 % patients).[33] This is contrary with Macchia A et al. (2012) who reported a much higher percentage 13.7 % respectively.[35] The disparity is most likely due to larger number of patients included in these studies compared to our study where the numbers of patients were less.

Tricuspid regurgitation was seen in 43 (30.7 %) patients of which 2 (4.6 %), 7 (16.2 %), 16 (37.2 %) and 18 (41.8 %) was seen in mild, moderate, severe and very severe GOLD COPD stage respectively. In a study by Higham MA et al. (2001) the presence of tricuspid regurgitation was seen in 56 (77 %) out of 73 COPD patients.[36] Tricuspid regurgitation was present in approximately 75 % of the patients in a study conducted by Mohammed YM et al. (2019).[30] The difference might be because of inclusion of only severe cases of COPD in other studies compared to our study where all stages of COPD were included accounting for higher percentage.

The presence of regional wall motion abnormality was seen in 11 (7.8 %) patients of which 4 (36.3 %) and 7 (63.6 %) were seen in severe and very severe GOLD COPD stage respectively. Our result was similar with Freixa X et al. (2013) who reported 4.1 % patients with regional wall motion abnormality.[29] However, regional wall motion abnormalities were present in 37.5 % of COPD patients in a study by Alexander V et al. (2015) with a sample size of 44.[28] The discrepancy could be due to smaller sample size resulting in overestimation.

Our study showed that pulmonary hypertension which is measured as pulmonary artery systolic pressure more than 25 mmHg was found in 28.5 %. This was in accordance with the results obtained by Freixa X et al. (2013) accounting for 19 %.[32] However, our result was not in agreement with El Wahsh et al. (2013) and Jatav VS et al. (2017) who showed that pulmonary hypertension was found in 55.6 % and 44 % of patients respectively.[37,38] This could be due to the fact that more severe stages of COPD patients were taken into consideration.

Left ventricular hypertrophy was seen among 24 (17.1 %) patients in our study of which 2 (8.3 %), 8 (33.3 %), 14 (58.3 %) were in moderate, severe and very severe COPD stages respectively. Gupta NK et al. (2011) reported 22.5 % of patients with left ventricular hypertrophy.[33] Similarly, Vallabhajosyula S et al. (2016) reported a higher prevalence of 42.5 % patients in 615 patients.[39] This could be due to the lesser number of participants in these studies.

Out of 140 patients, 30 (21.4 %) patients had normal echocardiographic findings. In a study conducted by Gupta NK et al. (2011) in 40 COPD patients, 50 % cases had normal echocardiographic parameters.[33] The percentages are quite high in these two studies owing to the fact that less sample size were taken.

CONCLUSIONS

In our study which included stable COPD patients, it was found that the disease was more prevalent in the male population and in the elderly age group. Maximum patients were in GOLD stage III and therefore with increasing severity of COPD, occurrence and severity of cardiac complications becomes more prevalent. The most common ECG findings were P pulmonale and RVH. PAH and TR were also common echocardiographic findings. However, a prospective study including a larger sample size with longer period of study is required to arrive at a definite conclusion.

Data sharing statement provided by the authors is available with the full text of this article at jebmh.com.
Financial or other competing interests: None.
Disclosure forms provided by the authors are available with the full text of this article at jebmh.com.

REFERENCES

[1] Gunen H, Hacievliyagil SS, Kosar F, et al. Factors affecting survival of hospitalised patients with COPD. Eur Respir J 2005;26(2):234-241.
[2] Jindal SK, Aggarwal AN, Chaudhry K, et al. A multicentric study on epidemiology of chronic obstructive pulmonary disease and its relationship with tobacco smoking and environmental tobacco smoke exposure. Indian J Chest Dis Allied Sci 2006;48(1):23-29.
[3] Rutten FH, Moons KG, Cramer MJM, et al. Recognising heart failure in elderly patients with stable chronic obstructive pulmonary disease in primary care: cross sectional diagnostic study. BMJ 2005;331(7529):1379.
[4] Sin DD, Lacy P, York E, et al. Effects of fluticasone on systemic markers of inflammation in chronic obstructive pulmonary disease. Am J Respir Crit Care Med 2004;170(7):760-765.

[5] Kolsum U, Roy K, Starkey C, et al. The repeatability of interleukin-6, tumor necrosis factor-α, and C-reactive protein in COPD patients over one year. Int J Chron Obstruct Pulmon Dis 2009;4:149-156.
[6] Castagna O, Boussuges A, Nussbaum E, et al. Peripheral arterial disease: an underestimated aetiology of exercise intolerance in chronic obstructive pulmonary disease patients. Eur J Prev Cardiol 2008;15(3):270-277.
[7] Blum A, Simsolo C, Sirchan R, et al. "Obesity paradox" in chronic obstructive pulmonary disease. The Israel Medical Association Journal: IMAJ 2011;1 (11):672-675.
[8] Pecci R, De La Fuente Aguado J, Sanjurjo Rivo AB, et al. Peripheral arterial disease in patients with chronic obstructive pulmonary disease. Int Angiol 2012;31(5):444-453.
[9] Mahender V, Akhila J, Sree Keerthi MV. A retrospective study on epidemiology of asthma and chronic obstructive pulmonary disease. J Pulmon Respir Med 2017;7(4):1000418.
[10] Serapinas D, Narbekovas A, Juskevicius J, et al. Systemic inflammation in COPD in relation to smoking status. Multidisciplinary Respiratory Medicine 2011;6(4):1-6.
[11] de Oliveira JCM, de Carvalho Aguiar I, de Oliveira Beloto ACN, et al. Clinical significance in COPD patients followed in a real practice. Multidiscip Respir Med 2013;8(1):43.
[12] Jain NK, Thakkar MS, Jain N, et al. Chronic obstructive pulmonary disease: does gender really matter? Lung India 2011;28(4):258-262.
[13] Folchini F, Nonato NL, Feofiloff E, et al. Association of oxidative stress markers and C-reactive protein with multidimensional indexes in COPD. Chron Respir Dis 2011;8(2):101-108.
[14] Soriano JB, Visick GT, Muellerova H, et al. Patterns of comorbidities in newly diagnosed COPD and asthma in primary care. Chest 2005;128(4):2099-2107.
[15] Sinha B, Vibha RS, Chowdhury R. An epidemiological profile of chronic obstructive pulmonary disease: a community-based study in Delhi. J Postgrad Med 2017;63(1):29-35.
[16] 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(1):63-70.
[17] Cazzola M, Rogliani P, Matera MG. Cardiovascular disease in patients with COPD. Lancet Respir Med 2015;3(8):593-595.
[18] Mapel DW, Dedrick D, Davis K. Trends and cardiovascular co-morbidities of COPD patients in the Veterans Administration Medical System, 1991–1999. COPD 2005;2(1):35-41.
[19] Hudson LD, Kurt TL, Petty TL, et al. Arrhythmias associated with acute respiratory failure in patients with chronic airway obstruction. Chest 1973;63 (5):661-665.
[20] Singh II, Susie K, Ningthoujam S, et al. Electrocardiographic changes in obstructive airway disease. Journal of Medical Society 2013;27(1):19-24.
[21] Holtzman D, Aronow WS, Mellana WM, et al. Electrocardiographic abnormalities in patients with severe versus mild or moderate chronic obstructive pulmonary disease followed in an academic outpatient pulmonary clinic. Ann Noninvasive Electrocardiol 2011;16(1):30-32.
[22] McAllister DA, Maclay JD, Mills NL, et al. Diagnosis of myocardial infarction following hospitalisation for exacerbation of COPD. Eur Respir J 2012;39(5):1097-1103.
[23] Warnier MJ, Rutten FH, Numans ME, et al. Electrocardiographic characteristics of patients with chronic obstructive pulmonary disease. COPD: 2013;10(1):62-71.
[24] Kinagi S, Patil S, Afiya S. Analysis of chronic obstructive pulmonary disease with clinical parameters, ECG and echo. Journal of Evolution of Medical and Dental Sciences 2014;3(57):12864-128681.
[25] Scott RC, Kaplan S, Fowler NO, et al. The electrocardiographic pattern of right ventricular hypertrophy in chronic cor pulmonale. Circulation 1955;11(6):927-936.
[26] Pinto HR, Hansoti RC. The ECG changes in chronic corpulmonale. J Assoc Phy India 1960;8:213.
[27] Agrawal SR, Joshi R, Jain A. Correlation of severity of chronic obstructive pulmonary disease with health-related quality of life and six-minute walk test in a rural hospital of central India. Lung India 2015;32(3):233-240.
[28] Alexander V, Pajanivel R, Menon KS, et al. Prevalence of cardiac comorbidities and its relation to severity staging of chronic obstructive pulmonary disease. Int J Curr Res Rev 2015;7(17):27-33.
[29] Freixa X, Portillo K, Paré C, et al. Echocardiographic abnormalities in patients with COPD at their first hospital admission. Eur Respir J 2013;41(4):784-791.
[30] Mohammed YM, ElShahid GS, Osman NM, et al. Cardiac evaluation of patients with chronic obstructive pulmonary disease using echocardiography. Egyptian Journal of Bronchology 2019;13(1):12-16.
[31] Mascarenhas J, Lourenço P, Lopes R, et al. Chronic obstructive pulmonary disease in heart failure. Prevalence, therapeutic and prognostic implications. Am Heart J 2008;155(3):521-525.
[32] Franssen FME, Rochester CL. Comorbidities in patients with COPD and pulmonary rehabilitation: do they matter? Eur Respir Rev 2014;23(131):131-141.
[33] Gupta NK, Agrawal RK, Srivastav AB, et al. Echocardiographic evaluation of heart in chronic obstructive pulmonary disease patient and its co-relation with the severity of disease. Lung India 2011;28(2):105-109.
[34] López-Sánchez M, Muñoz-Esquerre M, Huertas D, et al. High prevalence of left ventricle diastolic dysfunction in severe COPD associated with a low exercise capacity: a cross-sectional study. PloS One 2013;8(6):e68034.
[35] Macchia A, Moncalvo JR, Kleinert M, et al. Unrecognised ventricular dysfunction in COPD. Eur Respir J 2012;39(1):51-58.

[36] Higham MA, Dawson D, Joshi J, et al. Utility of echocardiography in assessment of pulmonary hypertension secondary to COPD. Eur Respir J 2001;17(3):350-355.
[37] El Wahsh RA, Ahmed MK, Yaseen RI. Evaluation of left ventricular function in patients with chronic obstructive pulmonary disease with or without pulmonary hypertension. Egyptian Journal of Chest Diseases and Tuberculosis 2013;62(4):575-582.
[38] Jatav VS, Meena SR, Jelia S, et al. Echocardiographic findings in chronic obstructive pulmonary disease and correlation of right ventricular dysfunction with disease severity. IJAM 2017;4(2):476-480.
[39] Vallabhajosyula S, Sundaragiri PR, Kanmanthareddy A, et al. Influence of left ventricular hypertrophy on in-hospital outcomes in acute exacerbation of chronic obstructive pulmonary disease. COPD 2016;13(6):712-717.