

Original Article

Evaluation of Pulmonary Hypertension in Chronic Obstructive Pulmonary Disease (COPD) by assessment of Chest X- Ray, ECG and Echocardiography

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Abstract: Chronic Obstructive Pulmonary Disease (COPD) is the top cause of death worldwide and a growing health care burden. Advanced COPD often causes pulmonary hypertension, affecting around 20% of patients. Severe PAH in COPD patients reduces median survival by 40 months. Early pulmonary hypertension identification in COPD patients is crucial. Physical examination, chest x-ray, ECG, and ECHO are non-invasive PAH screening procedures. This study found pulmonary hypertension in COPD patients by assessing chest X-ray, electrocardiographic, and echocardiographic findings and their correlation with ECG alterations. The study followed the cross-sectional observational study, in the national academy of medical sciences (NAMS), Bir Hospital, Kathmandu-Nepal. Patients who visited OPD or admitted with signs and symptoms of COPD diagnosed clinically, radiologically and/or by pulmonary function test (PFT), both male and female, in Bir Hospital. Each individual was chosen by simple random sampling method. N=100 cases were selected randomly by lottery over a period of one year. Patient's chart, patients's OPD card or structural questionnaire were used as the research instrument where Patients were selected for data collection by simple random sampling method like lottery among those who visited OPD or admitted in ward of Bir hospital with diagnosis of COPD by history, physical and radiological examination and/or PFT criteria. The highest COPD prevalence was in people 70 or older (42%), with 66% of these being women. The most common risk factor for COPD was smoking (75%). Chest x-ray abnormalities most often were significant pulmonary conus (76%) and cardiomegaly (63%).The majority of ECG abnormalities in COPD patients with pulmonary artery hypertension were P-pulmonale (84%), R/S ratio <1 in V5 or V6, right axis deviation (49%), and right bundle branch block (41%).83% of patients met RVH ECG criteria. Hence it concluded that ECHO is better than ECG and chest x-ray at detecting pulmonary hypertension in COPD, but ECG has good specificity and sensitivity for RVH and pulmonary hypertension, so chest x-ray and ECG should be routine testing.

Keywords: Pulmonary Hypertension, Chronic Obstructive Pulmonary Disease (COPD), Echocardiography

1. INTRODUCTION

Chronic Obstructive Pulmonary Disease (COPD) is the top cause of death worldwide and a growing health care burden. Current 3rd biggest cause of death. COPD caused over 3 million deaths in 2012, 6% of all deaths [1]. COPD causes chronic morbidity and mortality worldwide; many people suffer for years and die prematurely from it or its complications. COPD is characterised by chronic respiratory symptoms and airflow limitation, it includes

emphysema, which destroys lung alveoli and enlarges air spaces, bronchitis, which causes chronic cough and phlegm, and small airway disease, which narrows and reduces small bronchioles [2]. COPD is defined by spirometry-measured chronic airflow restriction, which frequently arises in the context of unhealthy environmental exposures, such as smoking [3]. Pulmonary hypertension, a serious COPD complication, may develop late in the disease's course due to hypoxic vasoconstriction of the small pulmonary arteries, causing intimal hyperplasia and later smooth muscle hypertrophy and hyperplasia. It has a poor prognosis. Even moderate COPD and smokers vulnerable to emphysema have aberrant pulmonary microvascular blood flow, which increases with disease progression [4]. Mean pulmonary artery pressure (PAP) of 20 mmHg and estimated systolic PAP >36 mmHg indicate pulmonary hypertension. COPD patients often have mild to moderate pulmonary hypertension, with <5% experiencing severe cases [5]. Right ventricular hypertrophy and right side heart failure can result from progressive pulmonary hypertension. Diameter of pulmonary artery is associated with likelihood of exacerbation, regardless of previous experience, suggesting that perturbations in pulmonary vasculature are substantial, but under recognized, drivers of COPD symptoms and exacerbations [6]. Pulmonary hypertension causes cor-pulmonale, or pulmonary heart disease, which alters RV structure and function in chronic lung disease. Once susceptible patients get cor-pulmonale, their prognosis deteriorate, regardless of cause. COPD and chronic bronchitis account for ~50% of corpulmonale cases, although any condition affecting the pulmonary vasculature or parenchyma can cause it [7]. High prevalence of pulmonary hypertension complicating severe COPD and low predictive power of lung indicators suggest screening all COPD patients for PH. It enhances COPD prognosis. REM sleep, exercise, and acute exacerbations raise pulmonary arterial pressure, causing right heart failure [8]. Preventing right heart failure requires early pulmonary hypertension detection and treatment. Most COPD prevalence, morbidity, and mortality data originates from wealthy nations. Even in these nations, COPD epidemiology data is hard to get and expensive [9]. Due to COPD's late diagnosis, prevalence and morbidity estimates grossly underestimate the disease's burden. This study examined COPD patients' clinical profiles, pulmonary hypertension development, and non-invasive methods for early detection, such as clinical features suggestive of right heart failure, chest x-ray, electrocardiographic, and echocardiographic changes. Stephen and Richard demonstrated in 1975 that echocardiography could monitor pulmonary artery pressure and resistance, reducing the need for frequent cardiac catheterization [10].

2. MATERIALS AND METHODS

The study followed the cross-sectional observational study, in the national academy of medical sciences (NAMS), Bir Hospital, Kathmandu-Nepal. Patients who visited OPD or admitted with signs and symptoms of COPD diagnosed clinically, radiologically and/or by pulmonary function test (PFT), both male and female, in Bir Hospital. Each individual was chosen by simple random sampling method. N=100 cases were selected randomly by lottery over a period of one year. Sample size was calculated by using the proportion formula,

$$N = z^2 p (1-p) / d^2$$

Where,

N=required sample size,

z=1.96 at 96% confidence interval,

p=Prevalence of pulmonary hypertension (51.43%) and

d=10% maximum tolerable error.

An investigator from India has reported a high prevalence of pulmonary hypertension (51.43%) of the admitted COPD cases(3).Using the above formula sample size came out to be 99.63(3).Thus, sample size is 99.63~100. Data collection was started after getting letter of permission from the hospital authority, Institutional Review Board(IRB), NAMS. All the doctors, nursing staffs and other concerned persons were informed about the study. Tools for data collection were patient's chart, patients's OPD card or structural questionnaire. Patients were selected for data collection by simple random sampling method like lottery among those who visited OPD or admitted in ward of Bir hospital with diagnosis of COPD by history, physical and radiological examination and/or PFT criteria. Interventions like ECG, chest x-ray, echocardiography and PFTs were done in Bir, hospital. ECG, X-ray and PFTs during the study

was done by respective technician whereas ECHO was done by cardiologist or DM resident in cardiology department of Bir, Hospital. Patients were asked about the duration of symptoms like cough, shortness of breath, amount, nature and diurnal variation of cough and severity of breathlessness. Patients with history of cough with expectoration for greater than 3 months duration in two consecutive years, with absent or minimal breathlessness were considered to have predominant chronic bronchitis. Patients with exertional dyspnea of long duration with minimal cough which are productive of only small quantity of mucoid sputum were considered to have predominant emphysema. Patients with history of productive cough for more than 3 months duration, in two consecutive years with breathlessness of long standing duration, were considered to have mixed pattern, or emphysema-bronchitis complex. Patients were also asked about history of pedal edema, distension of abdomen, puffiness of face, right hypochondriac pain, to know whether the patient had developed right ventricular dysfunction. Patients were asked about the history suggestive of bronchial asthma, tuberculosis, bronchiectasis, rheumatic heart disease, congenital heart disease, history of hypertension to exclude them from the present study. Clinical examination consisted of both general physical and systemic examination. Particular attention was given to the presence or absence of cyanosis and signs of right heart failure-pedal edema, tender hepatomegaly and raised jugular venous pressure. A detailed examination of respiratory, cardiovascular and per abdominal examination was carried out, to know the physical signs of COPD, presence of right ventricular hypertrophy or dilatation and right ventricular failure and pulmonary hypertension. The following signs are noted in respiratory system examination:-Tachypnea, hyperresonant note on percussion with obliteration of cardiac dullness, reduced air entry bilaterally with prolonged expiratory phase, high pitched rhonchi and crackles at different location. Data were entered in a master chart as well as in a SPSS 20 excel spread sheet and analysis was made manually as well as with the help of the computer using SPSS program and will be depicted as tables. Chi square test was carried out for testing the significance. P value was considered significant if it was <0.05 . While organizing and summarizing data, descriptive statistics was used whereas inferential statistics was used for drawing conclusion.

3. RESULTS AND DISCUSSION

3.1 Sex Distribution of the Patients

Total N=100 number of cases admitted in Medicine Department in Bir Hospital was randomly selected considering the inclusion and exclusion criteria over a period of one year. In this study, 66% of the patients were females and 34% were males.

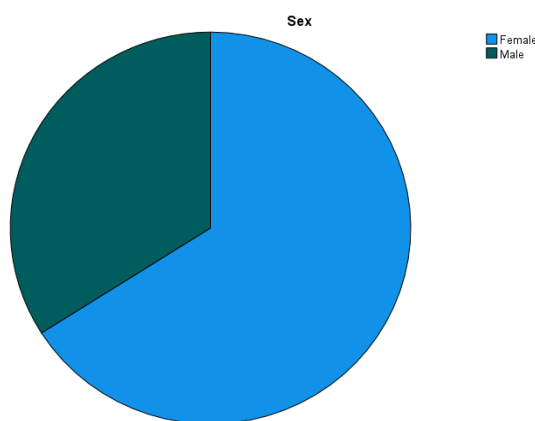
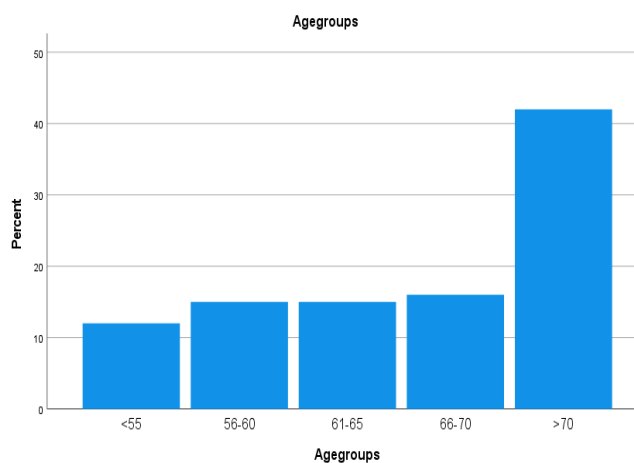


Figure 01: Sex distribution of the patients

The maximum incidence of COPD in this study found in patients aged 70 years or more (42%). The mean age of the patients is 69.10 years.

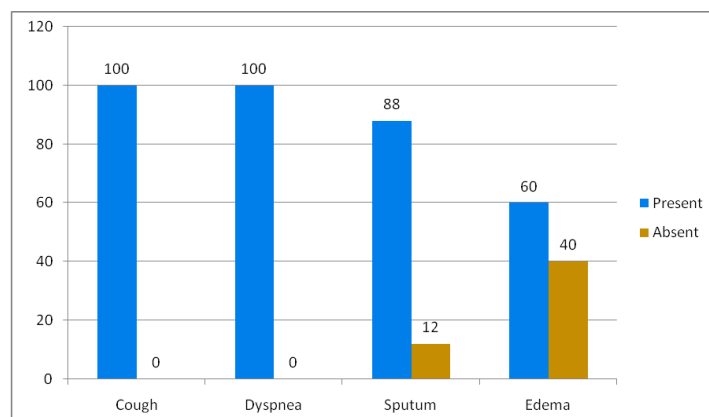
Table 01: Age distribution of the patients

Age in years	Frequency	Percentage (%)
<55	12	12.0
56-60	15	15.0
61-65	15	15.0
66-70	16	16.0
>70	42	42.0
Total	100	100.0

**Figure 02:** Age distribution of the patients

3.2 Symptoms of COPD

All the patients in this study had cough and shortness of breath. 88% of patients had sputum. Edema was present in 60 % of patients.

**Figure 03:** Symptoms at presentation

3.3 Signs of COPD

Among the signs depicted in bar below, 83% patients had loud P2, murmur of TR and features suggestive of right heart failure like, raised JVP, pedal edema and hepatomegaly. 60% patients had tender hepatomegaly and both legs pitting edema. Whereas JVP was raised in 67% patients. Cyanosis was present in 41% patients.

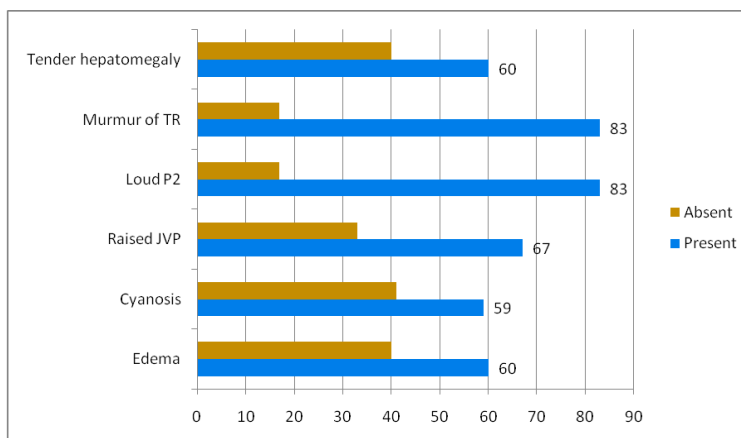


Figure 04: Signs at presentation

3.4 Chest x-ray Findings

In this study, 76% had prominent pulmonary conus on chest x-ray PA view, cardiomegaly is present in 63% of patients. X-ray features suggestive of emphysema was present in 57% of patients.

Table 02: Chest x-ray findings in the patients

X-ray finding	No. of cases	Percentage (%)
Prominent pulmonary conus	76	76
Cardiomegaly	63	63
Emphysema	57	57

3.5 ECG Findings

In this study, 83% patients had right ventricular hypertrophy, the most common ECG abnormality seen in COPD was P-pulmonale in 84%, followed by R/S ratio in V5 or V6 < 1 in 83%, followed by right axis deviation in 49% and RBBB in 41% patients.

Table 03: ECG findings in the patients

ECG	No. of cases	Percentage (%)
P-pulmonale	84	84
R/S in V5/V6 < 1	83	83
QRS axis (RAD $\geq 110^\circ$)	49	49
RBBB	41	41
RVH	83	83

3.6 Echo Findings

Features suggestive of cor-pulmonale like right ventricular hypertrophy and dilatation was present in 88% patients and tricuspid regurgitation was present in 91% patients. Most patients enrolled in the study had severe pulmonary

artery hypertension i.e in 68%, followed by moderate pulmonary hypertension in 24% and then mild pulmonary hypertension in 8% patients.

Table 04: Severity of Pulmonary hypertension

PASP(mm of Hg)	No. of patients	Percentage (%)
Mild(20-40)	8	8
Moderate(41-55)	24	24
Severe(>55)	68	68

3.7 Comparison of each X-ray findings with Pulmonary hypertension in ECHO

3.7.1 Prominent pulmonary conus

In total, prominent pulmonary conus was present in 76% COPD patients with pulmonary hypertension, no patients with mild pulmonary hypertension had prominent pulmonary conus in chest x-ray whereas 54.16% (13 patients) with moderate and 92.64%(63 patients) with severe pulmonary hypertension had prominent pulmonary conus in chest x-ray. P-value is not significant though data is statistically significant.

Table 05: Association of Prominent pulmonary conus (X-ray) and PASP

		Pulmonary artery systolic pressure(PASP)			Total	
		Mild (20-40)	Moderate (41-55)	Severe (>55)		P-value
Prominent pulmonary conus(X-ray)	Absent	8	11	5	24	0.711
	Present	0	13	63	76	
Total		8	24	68	100	

3.7.2 Cardiomegaly

Cardiomegaly was present in 63% COPD patients with pulmonary hypertension, 37.5% (3 in 8) patients with mild pulmonary hypertension had cardiomegaly in chest x-ray whereas 45.83%(11 in 24 patients) with moderate and 72.05%(49 in 68 patients) severe pulmonary hypertension had cardiomegaly in chest x-ray.

Table 06: Association of Cardiomegaly (X-ray) and PASP

		Pulmonary artery systolic pressure(PASP)			Total	
		Mild (20-40)	Moderate (41-55)	Severe (>55)		p-value
Cardiomegaly (X-ray)	Absent	5	13	19	37	0.381
	Present	3	11	49	63	
Total		8	24	68	100	

3.7.3 Emphysema

Features suggestive of emphysema were present in 57% COPD patients with pulmonary hypertension. 62.5% (5 in 8) patients with mild pulmonary hypertension had emphysema in chest x-ray whereas 58.33% (14 in 24 patients) with moderate and 55.88% (38 in 68 patients) severe pulmonary hypertension had emphysema in chest x-ray.

Table 07: Association of Emphysema (X-ray) and PASP

		Pulmonary artery systolic pressure(PASP)			Total	
		Mild (20-40)	Moderate (41-55)	Severe (>55)		P-value
Emphysema (X-ray)	Absent	3	10	30	43	0.502
	Present	5	14	38	57	
Total		8	24	68	100	

3.8 Comparison of each ECG findings with pulmonary hypertension in ECHO

3.8.1. P-pulmonale

P-pulmonale was the most common abnormality in ECG which was found in 84 % patients with pulmonary hypertension. It was present in 12.5% (1 in 8) patients with mild PAH, 75% (18 in 24) patients with moderate PAH and 95.58% (65 in 68) patients with severe PAH

Table 08: Association of P-pulmonale and PASP

		Pulmonary artery systolic pressure(PASP)			Total	
		Mild (20-40)	Moderate (41-55)	Severe (>55)		P-value
P-pulmonale	Absent	7	6	3	16	0.775
	Present	1	18	65	84	
Total		8	24	68	100	

3.8.2. R/S ratio<1 in V5 or V6

R/S ratio<1 in V5 or V6 was found in 83 % patients with pulmonary hypertension, it was present in 87% (7 in 8) patients with mild PAH, 87% (21 in 24) patients with moderate PAH and 80.88%(55 in 68) patients with severe PAH.

Table 09: Association of R/S<1 in V5 or V6 with PASP

		Pulmonary artery systolic pressure(PASP)			Total	P-value
		Mild (20-40)	Moderate (41-55)	Severe (>55)		

R/S inV5 or V6<1	Absent	1	3	13	17	0.755
	Present	7	21	55	83	
Total		8	24	68	100	

3.8.3. QRS axis (Right axis deviation)>110

Right axis deviation was found in 49 % patients with pulmonary hypertension, RAD was present in 75% (6 in 8) patients with mild PAH,50%(12 in 24) patients with moderate PAH and 45.58%(31 in 68) patients with severe PAH. Data showed that prevalence of right axis deviation has inverse relation with increasing severity of pulmonary hypertension.

Table 10: Association of QRS axis (RAD)>110 with PASP

		Pulmonary artery systolic pressure(PASP)			Total	P-value
		Mild (20-40)	Moderate (41-55)	Severe (>55)		
QRS axis(RAD)>110	Absent	2	12	37	51	0.340
	Present	6	12	31	49	
Total		8	24	68	100	

3.8.4. Right bundle branch block (RBBB)

Right bundle branch block was found in 41 % patients with pulmonary hypertension, RBBB was present in 62.5% (5 in 8) patients with mild PAH,25.83% (11 in 24) patients with moderate PAH and 36.76% (25 in 68) patients with severe PAH. Data showed that prevalence of RBBB has inverse relation with increasing severity of pulmonary hypertension.

Table 11: Association of RBBB and PASP

		Pulmonary artery systolic pressure(PASP)			Total	P-value
		Mild (20-40)	Moderate (41-55)	Severe (>55)		
RBBB	Absent	3	13	43	59	0.304
	Present	5	11	25	41	
Total		8	24	68	100	

3.8.5 Right Ventricular Hypertrophy(RVH)

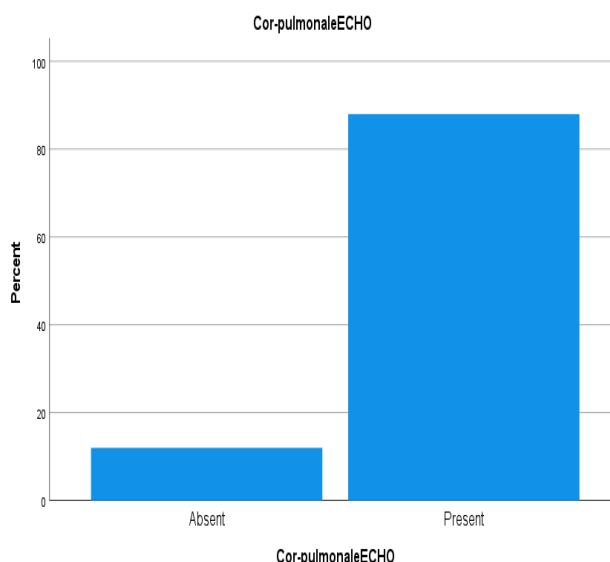
RVH was found in 83 % patients with pulmonary hypertension. RVH was present in 87.5% (7 in 8) patients with mild PAH,87.5%(21 in 24) patients with moderate PAH and 80.88%(55 in 68) patients with severe PAH

Table 12: Association of RVH with PASP

		Pulmonary artery systolic pressure(PASP)			Total	P-value
		Mild (20-40)	Moderate (41-55)	Severe (>55)		
RVH	Absent	1	3	13	17	0.545
	Present	7	21	55	83	
Total		8	24	68	100	

3.8.6 Cor pulmonale by ECHO

In this study, 88% patients had features suggestive of cor pulmonale i.e. right ventricular hypertrophy and/or dilatation.

**Figure 5:** Percentage cor pulmonale by Echo

3.2 Discussion

In this study female to male ratio was 1.5 i.e. female form 66% of the study subjects, higher incidence of COPD in females can be attributed to higher incidence of smoking and exposure to household biofuel smoke among females in Nepal. The highest incidence of COPD in the present study was in the age group >70 years (42%), almost 90% (88%) of the patients belonged to age more than 55 years. Similar prediction for elderly age group was found in other studies also [11]. A study observed maximum incidence in 51-70 age group (58%), while in PS Shankar's series it was in age group of 41-60 years (68%). 75% of patients in the study group were smokers, and had smoking history of more than 20 years [12]. The major symptoms were chronic cough with expectoration and dyspea on exertion and/or rest, breathlessness and cough were found in all patients whereas sputum was present in 88% patients [13]. Breathlessness is the symptom that commonly causes the patient to seek medical attention, and is usually the most disabling of these symptoms. Patients often date the onset of their illness to an acute exacerbation of cough with

sputum production [14]. Clinical signs of right ventricular hypertrophy was present in 83% of patients. The higher incidence of the most of the signs of RVH, pulmonary hypertension and CHF can be explained by the fact that most of the patients this study included patients admitted with exacerbation of COPD [15]. In this study 83% of the patients had ECG evidence of RVH, with criteria used as given by WHO, the incidence of RVH by ECG varies in different studies, depending on the number of patients in cor-pulmonale in the study, and the criteria used by the authors [16]. P-pulmonale has been used as an indirect evidence of right ventricular hypertrophy by various authors. The rates at which dependable images could be obtained by echo-cardiographic examination in patients with COPD have shown a wide variation by different authors and in different views. The presence of successful echo studies ranged from 91% [17]. Due to the high success rate of echocardiography to detect pulmonary hypertension and cor-pulmonale, other methods of detection of pulmonary hypertension like chest x-ray and ECG has been compared with echo findings of pulmonary hypertension in this study [18]. In our study, most of the patients (68%) had severe pulmonary hypertension, and 24% had moderate pulmonary hypertension. As patients with features of pulmonary hypertension in COPD were included in the study, it was not comparable with other studies. Comparison of chest x-ray and ECG with ECHO in diagnosis of pulmonary hypertension, this study shows that echocardiography is better than chest x-ray and ECG to detect the presence of pulmonary hypertension and cor-pulmonale. Physical examination can reveal increased jugular venous distention, a tricuspid regurgitant holosystolic murmur and a loud P2, all suggestive of elevated right-sided pressure. Lung sounds are usually normal. Hepatomegaly, peripheral oedema, ascites and cool extremities characterize patients in a more advanced state with right ventricular failure at rest. Though chest radiograph is inferior to ECG in detecting pulmonary hypertension, it may show evidence of underlying lung disease [19]. In 90% of pulmonary arterial hypertension patients the chest radiograph is abnormal at the time of diagnosis [20]. The finding include central pulmonary arterial dilatation which contrasts with pruning of the peripheral blood vessels. Other study findings are comparable to this study, central pulmonary arterial dilatation i.e. prominent pulmonary conus is present in 76% patients in this study which is the most sensitive and specific x-ray changes that is evident in pulmonary hypertension. Prominent pulmonary conus becomes more evident with increasing severity of pulmonary hypertension. In this study 92.64% (63 patients in 68) patients with severe pulmonary hypertension had prominent pulmonary conus. Cardiomegaly was significantly more common in patients with COPD group presented in right heart failure. In this study, diagnosis of pulmonary hypertension and cor-pulmonale could be made in 83% by electrocardiography. ECG criteria for detecting right ventricular hypertrophy have high specificity (100%) and sensitivity (84%). The difficulty in interpreting the ECG criteria for RVH in COPD is due to the result of positional changes in the heart as a result of severe emphysema rather than RVH per se. In this study, ECG features suggestive of P-pulmonale (84%) and R/S ratio in V5 or V6 <1 (83%) were invariably present in patients with proven pulmonary hypertension whereas complete or incomplete RBBB (41%) and right axis deviation (49%) were present in less number of patients. Similar to x-ray changes of prominent pulmonary conus, electrocardiographic changes like p-pulmonale and deep r wave in V5 or V6 were also more evident with increasing severity of pulmonary hypertension [21]. P-pulmonale was present in 12.5% (1 in 8) patients with mild PAH, 75% (18 in 24) patients with moderate PAH and 95.58% (65 in 68) patients with severe PAH. Whereas R/S ratio in V5 or V6 <1 was present in 87% (7 in 8) patients with mild PAH, 87% (21 in 24) patients with moderate PAH and 80.88% (55 in 68) patients with severe PAH [22]. Echocardiography in COPD is not without inherent drawbacks, the sub-sternal location of the right ventricle in chest making correct direction and angulation of the echo probe extremely uncertain and thick barrier of the air in emphysematous chest preventing adequate penetration by ultrasonic waves [23]. But most studies report that adequate examination can be obtained in more than 70% of the patients, reliable ECHO measurements obtained is 80% [24]. However this study had included patients with proven ECHO evidence of pulmonary hypertension so that comparison could be done with ECHO to find out diagnostic association of different chest x-ray and ECG changes. It found that ECG had a sensitivity of 31% and specificity of 85% and ECHO had a sensitivity of 93% and specificity of 95% in detecting the RV dysfunction [25]. Similarly a study found that diagnosis of cor-pulmonale by ECG could be made in 78% and by ECHO in 95% of the patients [26]. As study found that sensitivity and specificity for diagnosis of pulmonary hypertension in patients with COPD by ECG was 51% and 86% respectively and by ECHO was 78% and 78% respectively [27]. Pulmonary hypertension is a common feature of advanced COPD and is estimated to affect $\geq 20\%$ of patients with advanced

COPD [28]. The vast majority of pulmonary hypertension associated with COPD is mild, moderate to severe pulmonary hypertension occurs in <5% of patients with COPD [29]. Severe PAH in patients with COPD reduces median survival by 40 months, however, in this study majority of patients had moderate to severe pulmonary hypertension, cause possibly being enrollment of patients admitted with exacerbations of COPD [30]. Hence early diagnosis of pulmonary hypertension in COPD patients have important value. As discussed in this study, non-invasive methods like physical examination, chest x-ray, electrocardiogram and ECHO have extra benefits for early diagnosis of PAH.

4. CONCLUSIONS

Chronic Obstructive Pulmonary Disease (COPD) is a major cause of health care burden worldwide and the leading cause of death which is increasing in prevalence. Currently, it is the 3rd leading cause of death. More than 3 million people died of COPD accounting for 6% of all deaths globally. Pulmonary hypertension is a common feature of advanced COPD and is estimated to affect $\geq 20\%$ of patients with advanced COPD. Severe Pulmonary arterial hypertension (PAH) in patients with COPD reduces median survival by 40 months. Hence, early diagnosis of pulmonary hypertension in COPD patients have important value. Non-invasive methods like physical examination, chest x-ray, electrocardiogram and ECHO have extra benefits for early detection of PAH. This study identified the pulmonary hypertension in COPD patients by assessment of chest X-ray, electrocardiographic and echocardiographic findings and to find out association of chest X-ray and ECG changes in diagnosing pulmonary hypertension. COPD is a common disease among respiratory patients admitted in the hospital. It is more common in females in the 5th to 7th decade of life, smoking and exposure to various dusts and biofuels are the major risk factors in causation of COPD. Most patients have advanced disease at presentation in form of severe pulmonary hypertension with cor-pulmonale in right heart failure. Non-invasive methods like clinical features suggestive of right heart failure, chest x-ray and electrocardiographic changes can be used as a diagnostic tool for detection of pulmonary hypertension. Though ECHO is better than ECG and chest x-ray in detecting pulmonary hypertension in COPD, ECG has a high specificity and sensitivity for diagnosis of RVH and hence pulmonary hypertension, so chest x-ray and ECG should be done as a routine investigation in COPD.

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