Clinical and Radiological Evaluation of Emphysematous Chest - A Prospective Study

Yash Sharma[1], Pradeep Bansal[2], Sonal Saran[3], Sameer R. Verma[4]

ABSTRACT

Introduction: Worldwide, COPD is the major cause of health care burden and the only leading cause of death that is increasing in prevalence. Hence present study was undertaken to correlate clinical and radiological findings of Pulmonary Emphysema. Imaging spectrum of Emphysema was analysed by chest X ray and computerized tomography and they were correlated with stages of COPD as per GOLD guidelines based on PFT.

Material and Methods: The source of data for this prospective study were 150 patients with probable diagnosis of COPD referred to our department of Radio diagnosis. After informed consent, clinical history and clinical examination was done. PFT, chest radiographs and CT were performed.

Results: There was a significant association between X ray finding with PFT and CT findings with PFT with *P* Value 0.001 and *P* value 0.0002 respectively using Fischer's exact test. There was a significant association between the features like hyperinflation, bullae and tubular heart noted on X ray with CT. CT was much more sensitive in diagnosis of emphysema in even mild type of COPD.

Discussion: COPD is a disease of old age and is associated with prolonged duration of exposure to smoke and noxious particles. CT is undoubtedly more sensitive(100%) than chest radiographs in diagnosing emphysema and in determining its type and extent and has a significant association with PFT.

Conclusion: This hospital based study had limitations of small sample size and inherent bias, but clearly shows that CT has important diagnostic role in Emphysema with high sensitivity and specificity.

Keywords: Clinical and Radiological Evaluation, Emphysematous Chest

INTRODUCTION

The Global Initiative for Chronic Obstructive Lung Disease (GOLD) and World Health Organization (WHO) defines Chronic obstructive pulmonary disease (COPD) as "a common preventable and treatable disease, that is characterized by persistent respiratory symptoms and airflow limitation that is due to airway and/or alveolar abnormalities usually caused by significant exposure to noxious particles or gases".[1] It is characterized by chronic airflow limitation which is caused by a mixture of small airway diseases (Obstructive bronchiolitis) and parenchymal destruction (emphysema).[1]

Worldwide, COPD is the major cause of health care burden and the only leading cause of death that is increasing in prevalence. It is the fourth leading cause of death, and by 2020, is expected to rise to the 3rd position as a cause of death.[2]

The most characteristic symptom of COPD is chronic and progressive dyspnea. Cough with sputum production is present in upto 30% of patients. Significant airflow limitation may also be present without chronic dyspnea and/or cough and sputum production and vice versa.[3]

Tobacco smoking continues to be a major cause of COPD. Pathogenesis of COPD includes chronic inflammation throughout the airways, parenchyma, and pulmonary vasculature. Among these changes, destruction of the lung parenchyma is commonly referred to as pulmonary emphysema.[1]

Emphysema is defined as a "condition of the lung characterized by abnormal, permanent enlargement of the air spaces distal to the terminal bronchioles, accompanied by destruction of alveolar walls and without obvious fibrosis".[4]

Fleischner society classified Emphysema into different types based on anatomical distribution of areas of lung destruction as:[5]

Centrilobular Emphysema (CLE)

CLE (proximal or centriacinar) is defined by preferential loss of alveolar septa in the centers of pulmonary acini and pulmonary lobules, in relation to respiratory bronchioles.[5]

On HRCT there is presence of multiple small lucencies predominantly in upper lobes.

Panlobular Emphysema (PLE)

PLE is defined by uniform loss of alveolar septa throughout secondary lobules with lack of visible walls in emphysematous areas.[5] It typically results in an overall decrease in lung attenuation. Involved lung appears abnormally lucent, and pulmonary vessels in the affected lung appear fewer and smaller than normal and may be quite inconspicuous.

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Paraseptal Emphysema

Paraseptal (distal acinar) emphysema results in the presence of subpleural lucencies, which are often very thin walled; these walls may correspond to interlobular septa. It affects the most distal parts of the acinus, the alveolar sacs and ducts, and spares the respiratory bronchioles. It occurs mostly in the upper lobes, but can involve the posterior lower lobes.[5] These are illustrated in figure2.

Bullous Emphysema

A bulla has been defined as a sharply demarcated area of emphysema measuring 1 cm or more in diameter and possessing a thin epithelialized wall that is usually no thicker than 1 mm. When emphysema is associated with predominant bullae, it may be termed bullous emphysema.[6]

In most cases, the diagnosis of emphysema can be made with a combination of the clinical findings, pulmonary function test results and chest radiographs. Computerised Tomography(CT) is the most accurate method for diagnosis emphysema in vivo, but its role in clinical assessment is limited because of its cost. Pulmonary function tests (PFT) widely used in respiratory clinics, provides established measurements of lung function that are widely accepted for the diagnosis and monitoring of COPD; however, these tests are insensitive to early disease changes, progression of the disease and response to treatment.[7] Figure 1 shows the X ray and CT images of a patient with bullous emphysema.

Study aimed at analysis of imaging spectrum of Emphysema on Chest radiographs, the evaluation of additional findings detected by CT and define its role in diagnosis of Emphysema and correlation of imaging findings with spirometry.

MATERIAL AND METHODS

The source of data for this study were 150 patients with probable diagnosis of Chronic Obstructive Pulmonary disease referred to the department of Radio diagnosis, Imaging and interventional radiology from Pulmonary Medicine OPD/IPD of C.S.S. Hospital, under the ageis of N.S.C.B Subharti Medical College, Meerut for a period of 18 months, from October 2016 to March 2018.

After taking informed consent, a detailed clinical history was recorded of each patient and relevant clinical examination was done. PFT was done and chest radiographs were taken in all the patients before subjecting them to CT examination. Respiratory Disease other than emphysema were excluded.

PFT

Parameters used for diagnosis of COPD in our study included:

- Forced expiratory volume in one second (FEV_1)
- Forced vital capacity(FVC)
- FEV_1/FVC ratio

The GOLD criteria[1] for severity of COPD is usually assessed on the basis of a single parameter –FEV1 and it has been shown in Table 1.

Chest radiography

Posterior-anterior (PA) view was performed in every patient and parameters which were recorded include:

Increased Lung Volume

≥29.9 cm from the dome of the right diaphragm to the first rib.

Flattening of the right hemidiaphragm with a height < 1.5cm.

Right hemidiaphragm at or below the level of the anterior 7th rib.

Blunting of the lateral costophrenic angles.

Visible diaphragmatic slips.

Tubular heart.

Lung Destruction

Bullae

Lung lucencies

High resolution Computed tomography (HRCT)

The following features were evaluated using HRCT[8]

1. **Hyperinflated Lung Fields:** Increased length of anterior junctional line.
2. **Bullae:** Destruction of lung parenchyma.
3. **Flattening of diaphragm.**
4. **Centriacinar, Panacinar, Paraseptal emphysematous changes.**
5. **Tracheal index**: A ration of transverse to antero-posterior diameter at a plane 1 cm above the aortic arch. When the tracheal index was less than 2/3(0.67) it is called Saber sheath trachea
6. **Thoracic cage ratio**: It is a ratio of antero-posterior to transverse diameter. It was evaluated at two planes: (A) carina and (B) 5 cm below carina. It is generally >0.75 in emphysema.
7. **Sterno-aortic distance**: Distance from posterior surface of the sternum to anterior margin of the aortic at carinal level. It is less than or equal to 4cm in emphysema.
8. **Mosaic attenuation pattern**: Non homogenous lung density with areas that remain relatively lucent interspersed with areas of normal or higher lung density.

These features are illustrated in figure 3.

STATISTICAL ANALYSIS

All statistical analysis were performed with SPSS version 21.0 software. P value was calculated by using Fischer's exact test.

RESULTS

In our study of 150 patients, the most common age group involved was 50-70 years of age (mean 57.68 ± 11, age range 30-80 years). Out of them there were 118 (78.6%) male patients. The duration of disease ranged from 3 to 22 years (mean 16.8 ± 6.8). On the basis of disease severity based on GOLD classification, the patients were divided into four groups, maximum patients were in GOLD stage III. Most of the patients belonged to rural population (84%) and were farmers (48%) followed by laborers (23%). Regarding smoking status 113 patients were smokers (75%). Cough (93%) and breathlessness (80%) were the most common complaints followed by wheeze and chest pain.

Chest X ray findings and CT findings correlated with PFT are enumerated in Table 2.

There was a significant association between chest X ray

Gold Stage	Severity	Symptoms	Spirometry
I	Mild	With or without chronic cough or sputum production	FEV_1/FVC<0.7 and FEV_1>80% Predicted
II	Moderate	With or without chronic cough or sputum production	FEV_1/FVC<0.7 and $FEV_1$50-80% Predicted
III	Severe	With or without chronic cough or sputum production	FEV_1/FVC<0.7 and FEV_1 30-50%Predicted
IV	Very Severe	With or without chronic cough or sputum production	FEV_1/FVC<0.7 and FEV_1<30% or FEV_1/FVC<0.7 and FEV_1<50% with respiratory failure or signs of right heart failure

Table-1: Gold criteria for copd severity

S.No.	Parameters	Mild (11)		Moderate(62)	Severe(66)	Very severe(11)
X ray Findings						
1	Hyperinflation	1	1	25	43	11
2	Increased lucency	5	5	25	32	8
3	Tubular heart	2	2	20	32	4
4	Bullae	0	0	10	9	2
5	Diaphragm flat	0	0	27	23	6
CT Findings						
1	Hyperinflation		6	47	51	11
2	Tubular		5	39	46	11
3	Mosaic		1	11	29	3
4	Centriacinar		9	39	43	10
5	Paraseptal		5	38	30	6
6	Panacinar		4	10	14	5
7	Bullae		0	31	40	7
Mean CT parameters in different Grades of COPD						
1	Tracheal index		.92±.02	.77±.07	.58±.068	.468±.17
2	Thoracic cage ratio		64.55±1.51	71.35±2.26	74.05±2.18	75.55±.934
3	Sternoaortic distance		2.14±.17	2.94±.56	3.90±.454	4.2±.16

Table-2: Chest X-ray and CT findings with PFT correlation (present cases)

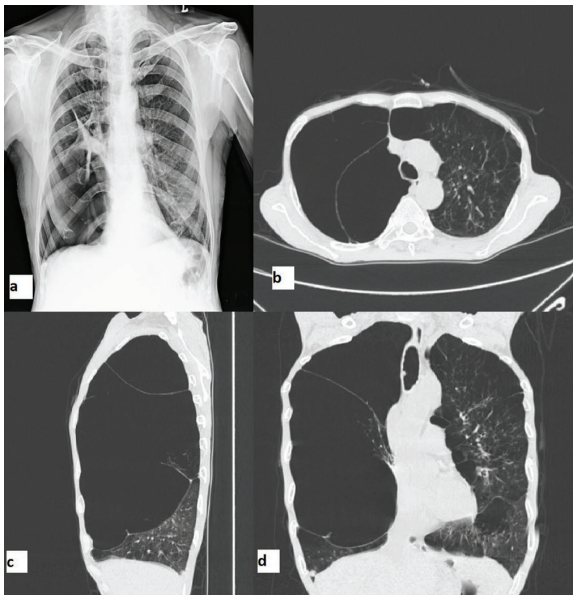

Figure-1: a). Chest X ray PA view showing hyperinflation, tubular heart, flattening of domes of diaphragm and large emphysematous bullae in right side of chest. CT images b), c), d). axial, sagital, coronal images respectively showing hyperinflation, lung destruction, large emphysematous bullae on right side and paraseptal emphysematous changes on left side. PFT in this showed decreased FEV1 less than 30% suggestive of very severe type of COPD.

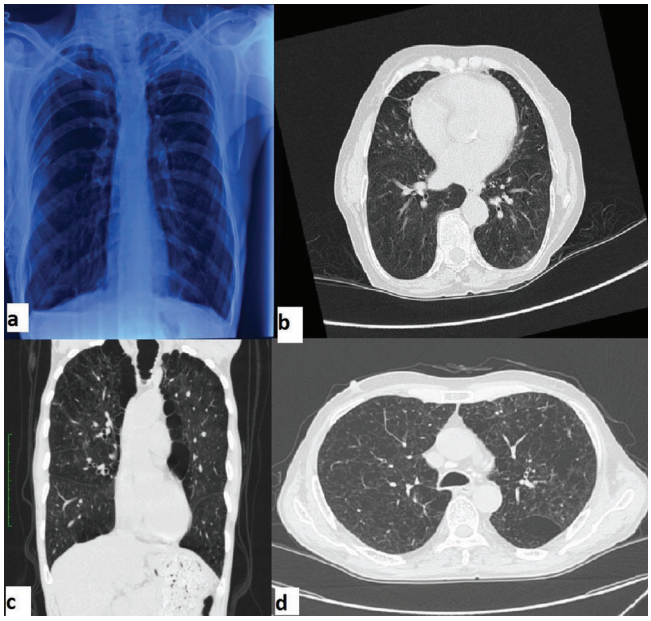

Figure-2: a). Chest X ray showing hyperinflation, tubular heart, flattening of dome of diaphragm. b). Axial CT image showing small scattered lucencies suggestive of centriacinar type. c), Coronal CT image showing paraseptal emphysematous changes. d). Axial CT image showing overall decreased lung attenuation, and lung destruction seen at places in the parenchyma.

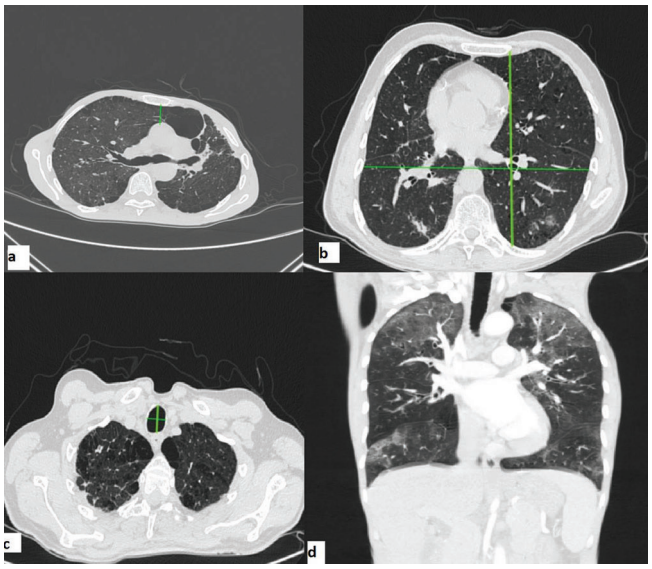

Figure-3: a). Sterno-aortic distance, b). Thoracic Cage ratio c). Tracheal Index d). Mosaic Attenuation are descripted in various CT images respectively.

finding and PFT with *P* Value 0.001 using Fischer's exact test. There was a significant association noted between CT findings and PFT with *P* value 0.0002 using Fischer's exact test.

There was a significant association between the features like hyperinflation, bullae and tubular heart noted on chest X ray with CT. CT was much more sensitive in diagnosing cases of emphysema in even mild type of COPD. Chest X Ray had sensitivity of only 53%.

Most common type of emphysema found was of Centriacinar type. Maximum number of Bullae were found in apical region followed by lingual and then at upper lobes.

DISCUSSION

COPD is a disease of old age and is associated with prolonged duration of exposure to smoke and noxious particles. Our findings (mean age 57. 68 ± 11) were also in conformity with Chugh T et al[9] where mean age was 61.5 years. Regarding patient sex there were 118 (78.6%) males which was in agreement with Wang et al[10] who found that prevelance of emphysema is higher in men than women.

75% of patients in the study group were smokers, and had smoking history of more than 20 years. It was comparable to Singh et al study.[11] Cough and dyspnoea were the most common complaints and grade of breathlessness increased with increasing disease severity. In a study done by Mahesh et al[12] 100% of patients presented with cough. According to GOLD staging, the patients in our study were divided in four groups. Maximum patients in our study were in GOLD Stage III (*n* = 66, 44%).

In our study out of 150 patients 80 patients had hyperinflation(53%) on chest radiograph, 58 chest X rays showed flattening of diaphragms and only 21 of them showed evidence of bullae. In very severe type of COPD there were 11 patients and all were showing hyperinflation. In Severe type there were 66 patients out of which 43 patients showed hyperinflation on chest X ray. In Moderate type 25 out of 62 patients showed hyperinflation and in mild type 1 chest x-ray showed hyperinflation out of 11. There was a significant association between stages of PFT and X ray findings with *P* value 0.011.

Similarly in a study done by Kiranjitet al[13] the emphysematous chest findings were encountered in advanced stage COPD as 33.4% of stage III and 68.4% of stage IV had former type of chest. Thus a strong statistical association between the PFT stage and X rays was observed.

On CT scan out of 150 patients, 100 patients showed tubular heart, 78(52%) patients showed tracheal index less than 2/3 (saber sheath trachea). Trigauxet al[14] mentioned that saber sheath trachea is a basically a sign of hyperinflation. He also found that saber sheath trachea was established as a specific radiographic diagnostic parameter in the diagnosis of emphysema specificity (92.95), although the sensitivity (39.1%) was low.

The thoracic cage ratio was more than 0.75 in 60 out of 150 patients (40%).

In our study, sterno aortic distance ≥4 cm was presented in 70 patients (47%). Hagen and Kolbenstvedt[15] reported that sterno- aortic distance was measured in CT sections at the carinal level if 4 cm or more is characteristic for emphysema. On comparing these findings with the grading of PFT, we found all patients with very severe type of emphysema showed hyperinflation and tubular heart on CT. 90% patients had centriacinar emphysema, 54% patients had paraseptal type, 33% patients showed panacinar emphysema, 63% had evident bullae. Mean sterno aortic distance noted was 4.2±0.16 i.e all patients in very severe stage had sterno aortic distance more than 4 cm. Tracheal index in very severe type averaged to 0.468±.17 and thoracic cage ratio percentage was more than 75 in all the patients. In our study, the correlation between HRCT and spirometry in the diagnosis of emphysema is considered moderate.

26% patients showed mosaic attenuation. Arakawa and Webb[16] mentioned that mosaic attenuation is more pronounced on scans obtained at end expiration compared to that found at end inspiration. This is the probable reason for detection of mosaic attenuation pattern in only 40 patients (26%).

In our study, 66% patients showed centriacinar emphysematous changes, 22% had panacinar type of emphysema, 52% patients had paraseptal type of emphysema, 53% patients showed bullae. Centriacinar emphysema is the commonest and is involved in the upper lobes. These results were in agreement with Takahashi Masashi et al[17] who reported that centriacinar emphysema is the commonest type of pulmonary emphysema and with the Wright[8] who mentioned that type is more common in the upper lung zones of the upper and lower lobes. In our study, panacinar emphysema was presented in 33 patients (22%) and is involved in the lower lobes. Lamb[18] mentioned that this type of emphysema is more prominent at the bases.

Richard Webb[18] mentioned that standard chest radiography and pulmonary function tests are insensitive for the early diagnosis of emphysema. CT is undoubtedly more sensitive

(100%) than chest radiographs in diagnosis emphysema and in determining its type and extent. If significant emphysema is found on HRCT, no further evaluation is necessary specifically, lung biopsy is not needed.

In a study by Klein et al[8], the sensitivity of chest radiography in the diagnosis of emphysema was 34%. COPD Guide Lines Group[19] mentioned that mild emphysema is difficult to detect on chest radiography.

Webb[18] mentioned that HRCT has excellent sensitivity in the diagnosis of COPD. Sanders et al[8] mentioned that CT is a more sensitive measure of mild emphysema than conventional lung function tests.

In our study, There were 11 patients with Mild type with average FEV1/FVC 61.68 and average FEV1 82.55±1.69, 62 patients in grade II or moderate type of COPD with mean FEV1/FVC 59.84 and FEV1 65.29, 66 patients with mean FEV1/FVC 51.58 and average FEV1 38.86±5 and 11patients were in very severe category with average FEV1/FVC 43.92±4 and mean FEV1 25.74±4.5.

CONCLUSION

This hospital based study had limitations of small sample size and inherent bias, but clearly shows that CT has important diagnostic role in Emphysema with high sensitivity and specificity. X rays are helpful ancillary findings but have low specificity. HRCT has much greater sensitivity than chest radiography in early diagnosing of emphysema and is also capable of differentiating between the various types of emphysema and assessing its severity. In addition a precise characterization of the emphysema by HRCT is desirable for adequate therapy and monitoring as well as a preoperative assessment of the patient before surgical treatment of emphysema. Compared to spirometry, HRCT shows the regional assessment of compartments involved (airways, parenchyma and vasculature). Moreover spirometry has no definite sensitivity.

There are certain cardinal features of emphysema that can be well-documented on HRCT. The various heterogenous groups under COPD can be differentiated and possible risk factors can be evaluated. COPD patients can be managed on the basis of the disease subtype.

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