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Research Article

HRCT FINDINGS IN EARLY CASES OF COPD- AN EXPERIENCE

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INTRODUCTION

COPD is characterized by airflow limitation that is not fully reversible. The airflow limitation is usually progressive and associated with an abnormal inflammatory response of the lung to noxious particles or gases. It is caused by a mixture of airway obstruction (obstructive bronchiolitis) and parenchymal destruction (emphysema), the relative contributions of which are variable (GOLD, 2006). Spirometry is essential for diagnosis and provides useful description of severity of pathological changes in COPD. Global Initiative for Chronic Obstructive Lung Disease (GOLD) defines COPD as a post-bronchodilator ratio of forced expiratory volume in one second to forced vital capacity (FEV1/FVC) of < 0.7. A very similar definition (post-bronchodilator FEV1/FVC $\leq$0.7) has been agreed on by the American Thoracic Society (ATS) and European Respiratory Society (ERS). The GOLD panel also stated that the chronic airflow limitation characteristic of COPD is caused by a mixture of small airway disease (obstructive bronchiolitis) and parenchymal destruction (emphysema), the relative contributions of which vary from person to person (Pauwels *et al.,* 2001).

GOLD (2007) guidelines divide COPD into Mild, Moderate, Severe, and Very Severe on the basis of spirometric findings. Mild and moderate cases are called as early cases of COPD.

HRCT is a promising method for evaluation of the inflammatory condition of the airway in COPD. It has lead to an increased interest in diagnosing emphysematous and chronic bronchitis components of COPD **(4)** and recent studies have shown that HRCT can be used to divide COPD patients into groups with predominant lower lung attenuation or thickening and narrowing of the airway, although many subjects have both abnormalities. Many studies have assessed HRCT features in patients with COPD, but there was a problem with non-uniformity regarding the included COPD patient population, and the various studies have evaluated for different HRCT features (Gupta *et al.,* 2009).

CT allows imaging of the lung without superimposition. In CT the air content of the lungs is used as the inherent contrast mechanism. Lung diseases cause a density change in the lung tissue. The density increases in alveolar and interstitial processes and decreases in chronic airway disease .Unenhanced functional CT of the lungs allows evaluation of perfusion differences of the lung parenchyma (mosaic perfusion), airway obstruction (air trapping) and breathing dynamics (Michael *et al.,* 2006)**.**

The specific morphologic changes in the central and peripheral airways, lung parenchyma, and pulmonary vasculature in COPD patients are well depicted by computed tomography (CT).CT can reveal what both clinical examinations and pulmonary function tests (PFTs) often cannot, namely the lesions that may mimic COPD and the predominance as well as the interplay between emphysema and airways disease (Sverzellati *et al.,* 2007). With the advances in the field of lung imaging, our ability to noninvasively quantify structural changes of the airways has been significantly improved in COPD, making it possible to establish a close relationship between structural and functional abnormalities. The variable proportion of emphysema, bronchial wall thickening and air-trapping – all common features of COPD – can be morphologically characterized by HRCT.

In this paper we present our study of 50 patients of early cases of COPD for various HRCT features

MATERIALS AND METHODS

This study was done on 50 patients of COPD from Jan 2008 to Jan 2010 in the department of Tuberculosis and Respiratory diseases, JN Medical College, Aligarh Muslim University.

Thorough clinical history was taken and detailed clinical examination was carried out. Diagnosis of COPD was done on the basis of Clinical features and Spirometry.

All patient underwent physiologic evaluation that included measurement of the forced expiratory volume in 1 second (FEV1), forced vital capacity (FVC), FEV1/FVC ratio, peak expiratory flow rate, (PEFR) using a Spirometer (P.K Morgan LTD, Kent England) using published predicted values. The patients showing FEV1/FVC less than 0.7 were selected for further study. Bronchodilator reversibility testing was done to differentiate irreversible airflow obstruction of COPD from reversible airflow obstruction of asthma. Chronic Obstructive Lung Disease (GOLD) criteria. (2007 UPDATE) was used to categorize COPD into Mild and Moderate. Mild cases were those who had FEV1 > and or equal to 80%. Moderate cases were those who had FEVI between 50 to 80%.

All patients underwent CT scans of the chest with a spiral CT scanner in high resolution mode (HRCT) according to the method of Mayo *et al*.,. In all subjects both end inspiratory and end expiratory HRCT scans were obtained using the following parameters; 125Kv, 310mAs, matrix size of 512x512, and a slice thickness of 1-1.25mm. A 20 cranial inclination of the gantry was used to improve CT analysis at segmental and sub segmental bronchi the scanning time ranged from 1.5 to 3 sec. A window level of 600 Hounsfield units was chosen with a width of 1,600 HU, as generally recommended for the analysis of the bronchi and lung parenchyma

The main purpose of the study was to note findings of early cases of COPD on HRCT

Inclusion criteria

- **History of dyspnoea, chronic cough or sputum production and /or history of exposure to risk factors for the disease**
- **Early cases (Mild and Moderate) of COPD diagnosed on the basis of Spirometry**
- Patients with post bronchodilator increase in FEV1<12%.

Exclusion Criteria

- An increase in FEV1 >12% or 200 ml, 10-15 minutes after inhaled salbutamol in a dose of 400 microgram was considered reversible obstruction and such patients were excluded from the study
- Severe and Very Severe COPD
- Recent respiratory tract infection in preceding six weeks Any other significant medical or surgical disease
- Pregnant females patients having tuberculosis or liver disease

HRCT findings noted in patients were following:

1. Bronchial Wall Thickening

It was considered to be present when bronchi or bronchioles were seen in the peripheral parts of the lungs, and it was graded by severity as mild(1-2mm), moderate 2-3 mm , and severe >3mm

2. Small Airways and Lung Parenchyma Abnormalities Included the Following

A. *Centrilobular structures* were determined as normal (barely visible), prominent(when A dot like, Y shaped, or X shaped opacity were seen a few millimetres away from the pleura or interlobular septa) or dilated(when a centrilobular structure was seen and assumed to represent a dilated bronchiole)

B. *Thick linear opacities* were determine as a nonseptal linear opacities or parenchymal bands more than 15mm in length that could correspond to linear scars, segmental, sub segmental or plate atelectasis

3. Emphysema was assesses by using following criteria

a. *Centrilobular emphysema* was considered to be present if HRCT scans showed focal areas of low attenuation up to 1 cm in diameter, within a homogenous background of lung parenchyma.

b. *Panlobular emphysema* was defined by large and extensive areas of uniformly low attenuation , associated with a reduction in size of pulmonary vessels

c. *Paraseptal emphysema* was considered to be present if multiple, small continuous , supleural air spaces ranging from a few millimetres to 1cm in diameter were visible on HRCT scans

d. *Irregular emphysema* was defined as emphysema adjacent to areas of parenchymal distortion

e. *The extend of emphysema* was graded as minimal, moderate and severe. Minimal has 0-5% of involvement of lung, moderate has 5-30% involvement of lung while severe has >30% involvement of

lung. Extend of disease on both sides was added and then mean was taken which was the final extend of disease.

4. **Mucoid Impaction**

Mucoid impactions in dilated bronchi were recognised as beaded densities , gloved finger and nodular or oval shaped densities seen on a few consecutive scans having a segmental distribution and being greater in diameter that the adjacent pulmonary arteries. Mucoid impactions in non dilated bronchi were recognised by opacities

5. **Air Trapping**

A. Mild; when only a small focal area that corresponded to less than three adjacent secondary pulmonary lobules was involved.

B. Moderate; when a small area between three adjacent secondary pulmonary lobules and a pulmonary segment was involved.

C. Severe; When an area greater than a pulmonary segment was involved

6. **Mosaic Attenuation Pattern**

It meant non-homogeneous lung density that later was described as areas that remain relatively lucent, interspersed with areas of normal higher lung density.

7. **Directly-visible Small Airways**:

The airways with an internal diameter of less than 2 mm.

8. **Vascular Attenuation**

It was considered when there was a thinning of pulmonary vessels and a reduction in their number.

9. **Vascular Distortion**

An increased branching angle and/or excessive straightening of pulmonary vessels was described as vascular distortion

RESULTS AND DISCUSSION

Results

The study comprised of 50 patients suffering from mild to moderate COPD. Out of 50 cases, 36*(72%)* cases were males, 14*(28%)* were females. Male to female ratio in the study was 5:2. Age of the patients in the study group varied from 40 to 70 yrs. No patient was less than 40 yrs of age (Table 1). Maximum numbers of patients were found in the age group of 61 to 70 years and maximum numbers of males and females were also seen in the same age group. The mean age was *58* years. Out of 50 patients, 24 patients (48%) had mild COPD with FEVI>and or = 80% and 26 patients (52%) had moderate COPD with FEVI 50%-80% (Table 2).

Twenty patients *(40%)* has evidence of emphysema on HRCT. Out of 24 patients with mild disease only 5 (21%) had evidence of emphysema. Out of 26 moderate disease patients 15 patients (57%) had evidence of emphysema on HRCT. The emphysema increased from 21% in mild COPD to 57% in moderate COPD. The increase in frequency is statistically significant. The most common emphysema which was found in maximum number of patients in both mild disease and moderate was Centriacinar (Figure 1) in 3 and 8 respectively followed by panacinar in 2 and 4 respectively. Paraseptal emphysema was seen in only 3 moderate cases (Table 3).

Minimal emphysema was seen in 80% of emphysema patients with mild COPD while 60% of emphysematous patients with moderate disease had severe emphysema. The extend of emphysema increased from none of patients with severe emphysema in mild to 60% of patients with severe emphysema in moderate disease. This increase in incidence of severe emphysema in moderate disease was *statistically significant* (Table 4).

Upper lobe was the most commonly involved lobe in patients with emphysema followed by middle lobe. The upper lobe was involved in *60%* of patients with emphysema in mild disease group while 67% of patients with emphysema in moderate group had involvement of upper lobe (Table 5).

Directly visible small airways (Figure 2a, 2b) is the most common HRCT findings in both mild and moderate COPD with 66.6% and 73% of patients respectively**.** *Vascular attenuation* was the second most finding in 50% and 66.6% of cases with mild and moderate COPD respectively. *Mucoid impaction* was seen in 8.3% patients of mild COPD while 15.3% patients of moderate COPD had these impactions. *Thick linear opacity, Centrilobular opacity and Mosaic attenuation* pattern was seen in 33.3%, 16.6%and 16.6% resp. of patients with mild COPD and in moderate COPD their frequency was 33.8%.23% and 34.6% (Table 6).

Air trapping was seen in 12.5 % of patients with mild COPD and in 38.4% of patients with moderate COPD.All patients with mild disease with air trapping had mild air trapping. Maximum no of patients in moderate group with air trapping had moderate air trapping (60%) followed by mild (30%) and severe (10%) (Table 7).

Bronchiectasis was seen in 8.3% in mild COPD and in 19.2%in moderate COPD. The most common lobe involved in bronchiectaisis was right lower lobe followed by right upper and the most common location was distal seen in 100% of mild and 60% of moderate disease. The most common type of bronchiectasis was cylindrical seen in 100% of patients with mild disease bronchiectasis while seen in 80% in moderate group. Varicose bronchiectasis was seen in 20% of moderate group (Table 8).

Bronchial wall thickening (Figure 3) was seen in 8.3% and 34.6% of patients with mild and moderate COPD respectively. Mild bronchial wall thickening was the most common thickening seen in both mild and moderate cases. While moderate bronchial wall thickening was seen in only moderate group (Table 9).

Discussion

The present study included patients attending outpatients at our medical college, with clinical features and chest radiographs suggestive of chronic airflow obstruction and the spirometry revealed irreversible or partly-reversible airflow obstruction indicative of early COPD. Sub typing of COPD as emphysema, chronic bronchitis or peripheral airways disease is not confidently possible through these conventional methods. There were significant differences in the patients' characteristics between previous studies and the present study. Some of these studies have either included only emphysema patients, chronic bronchitis patients or patients diagnosed as COPD on the basis of guidelines other than GOLD. Our inclusion criteria for COPD patients were based on GOLD guidelines (2007 update).

Maximum numbers of patients were found in the age group of 61 to 70 years and maximum numbers of males and females were also seen in the same age group. Thus the maximum patients were above 50 years. Our findings are in conformity with the findings of *Oswald et al.,* (1982). Who also reported the maximum incidence of chronic obstructive pulmonary disease in the middle decade of life. Kishore *et al.,* (1982) have also reported the mean age of patients of COPD as 49.17+- 16.5 yrs. In the present study out of 50 cases, 36(72%) cases were males, 14(28%) were females. Male: female ratio in the study was 5:2. Many workers have reported that disease is more predominant in males than females (Oswald, 1953).

During the last few decades, with the advent of high-resolution computed tomography (HRCT), there has been increased interest in diagnosing emphysematous and chronic bronchitis components of COPD using HRCT. The present study was undertaken to evaluate stable COPD patients for various HRCT features including vascular attenuation and distortion, mosaic attenuation pattern, directly visible small airways, low attenuation areas of emphysema.

An important finding of our study was the high prevalence of radiological bronchiectasis among patients diagnosed with COPD. We found that *8.3%* of mild disease patients and *19.2%* of moderate disease patients had bronchiectasis. O'Brien *et al.,* (2000) in 110 patients aged 40–80 years who had presented to their general practitioner with an acute exacerbation of COPD found HRCT evidence of bronchiectasis in *29%* of patients most *(81%)* were current or ex-smoker. Smith *et al.,* (1996) reported an incidence *of 68%* by HRCT scanning. Their results are opposite to our study. The presence of bronchiectasis on CT may provide a means of identifying those patients with COPD who are at risk of more severe disease.

Small centrilobular opacities were found in *16.6%* of mild and *23%* of patients with moderate COPD patients. While Harmanci *et al.,* (2002) found that small centrilobular opacities, caused by peribronchiolar inflammation and muscular hypertrophy, are found in *40.7% of* COPD patients. Lynch *et al.,* (1993) reported a proportion of *10%*.

Bronchial wall thickening was found in 2 patients of mild disease and 9 patients of moderate disease. Most of the bronchial wall thickening was mild. Nakano *et al.,* (2000) were the first to perform quantitative measurements of airway wall thickening in COPD patients and reported a significant correlation between wall thickness of the apical right upper lobe bronchus and FEV1% predicted. *Remy*-Jardin *et al.,* (2002) demonstrated bronchial wall thickening on HRCT in a third of smokers, but this was nonspecific, being present in 18% of non-smokers. Bronchial wall thickening, identifiable on HRCT, can result from airway inflammation that may be acute (e.g., lower respiratory tract infection) or chronic (e.g., asthma and cigarette smoking). The clinical weighting to be given to this subjective sign can be a source of difficulty when encountered in individuals with no known likely cause or associated respiratory disease. As yet, no robust threshold for calling abnormal bronchial wall thickness has been established. The effects of CT window settings on apparent bronchial wall thickening are well recognised. Lynch *et al.,* (1993) reported bronchial wall thickening in *19%* of their 'normal' controls, a finding that has not been reproduced in other studies.

Air-trapping is a key finding for depicting small airways obstruction on HRCT scans. Maximum number of patients with air trapping in our study had mild air trapping in mild cases and moderate air trapping in moderate cases while Tanaka *et al.,* (2003) reported that 13/26 (*50%*) healthy non-smoking subjects in their series had areas of air-trapping. Park *et al.,* (1997) reported that 14% of their healthy subjects had areas of air-trapping greater than a segment of lung in volume.

Vascular attenuation was seen in 12(50%) of mild and 16(66.6%) of moderate COPD which *had upper lung field* predominance. In study by Gupta *et al.,* (2009) 62.5% had vascular attenuation but their study was not restricted to early cases of COPD. Vascular distortion in emphysema occurs due to hyperinflation of the lungs. In the present study, this feature was observed in 4 in mild and ten in moderate patients while study by Gupta *et al.,* (2009) did not find any vascular distortion in early cases. It appears from our study that vascular distortion is also seen in early cases of emphysema.

Mosaic attenuation pattern was seen in *8* mild and *9* moderate patients on HRCT. All these patients had the associated features of vascular attenuation and directly visible small airways. *Copley et al.,* (2002) have suggested that the mosaic attenuation pattern in addition to other HRCT features is helpful in distinguishing between different entities grouped under COPD. Gupta *et al.,* (2009) found Mosaic attenuation in 40% of their study population

Normal small airways are not visible on HRCT. As there is a small airways component in heterogeneous entities grouped under COPD, these diseased airways are visible near the lung periphery on HRCT (Hansell, 2001). These diseased bronchioles are visible on HRCT as dilated, air-filled, branching, ring-like or tubular structures in the lung periphery due to wall thickening and dilation. When the airways are obliterated by sub mucosal or peribronchial fibrosis, nodular, linear or branching peripheral opacities are also seen (Teel *et al.,* 1996). In the present study, directly-visible small airways was the most common HRCT findings in both mild and moderate COPD seen in 16 (66.6%) of mild and 19 (73%) of moderate patients. A high percentage of our patients with this feature support the suggestion that intrinsic changes in the airways themselves may be far more important than has been previously thought. A study by Gupta *et al.,* (2009) on High-resolution computed tomography features in patients with chronic obstructive pulmonary disease also found directly visible small airways as the commonest finding (36 patients) but patients included both early and late cases. Hogg *et al.,* (1968) showed that, despite a decreased radius of small airways, airflow resistance is actually not increased because of the greater overall number of these peripheral bronchioles. Because most airflow resistance occurs at the level of the larger airways, significant disease must be present at the level of the peripheral airways to be detected on standard

pulmonary function tests (Teel *et al.,* 1996). HRCT hence has a definite edge in the diagnosis of small airways disease.

Figure 1: Showing Centriacinar emphysema

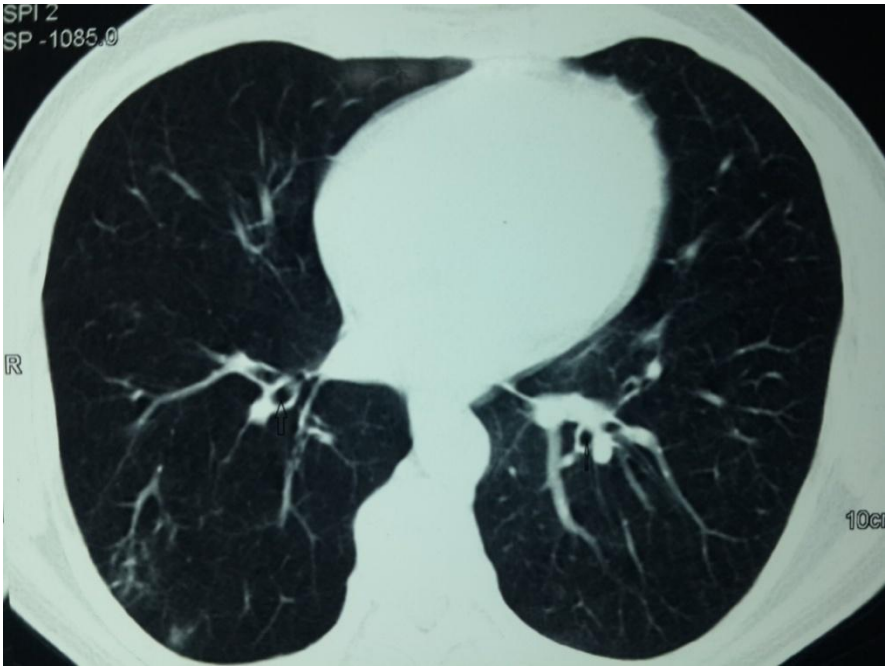

Figure 2a: Showing directly visible airways (Arrow)

Figure 2b: Showing directly visible airways (Arrow)

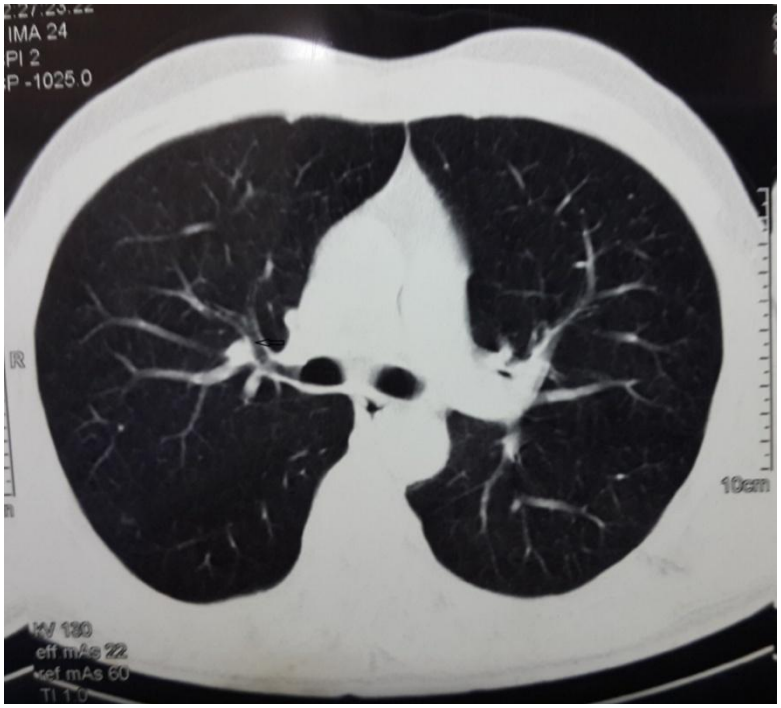

Figure 3: Bronchial wall thickening (Arrow)

Table 1: Age wise distribution of cases

Age groups	males	females	Total	Percent
40- 50	10	4	14	28
51-60	12	5	17	34
61-70	14	5	19	38

Table 2: Distribution of patients according to severity of disease

FEVI	No of patients	percentage	Severity of disease
> 80%	24	*48%*	Mild
50-80%	26	*52%*	Moderate

Table 3: No. of patients with different types of emphysema on HRCT

Emphysema	Mild	Moderate
Centriacinar	3	8
Panacinar	2	4
Paraseptal	0	3
Total No. of Patients	5	15

Table 4: No. of patients with extend of EMPHYSEMA on HRCT

Extent of emphysema	No of emphysema patients with mild COPD(5)	No of emphysema patients with moderate COPD(15)
MINIMAL EMPHYSEMA (>0% -5%)	4 (80%)	2 (13)
MODERATE EMPHYSEMA (>5% -30%)	1 (20%)	4 (27%)
SEVERE EMPHYSEMA (>30%)	0	9 (60%)

Table 5: Involvement of different lobes of lungs in patients having CT evidence of emphysema

Lobes of lung	No of patients with Mild disease	Moderate disease
upper	3	10
middle	1	3
lower	1	2

Table 6: HRCT findings and their severity according to clinical Severity groups in COPD

	Mild disease (24)		Moderate disease (26)	
HRCT Finding	**No. of patients**	**Percentage of mild**	**No. of patients**	**Percentage of moderate**
Vascular attenuation(2nd MC)	*12*	*50%*	*16*	*66.6%*
vascular distortion	4	16.6%	10	38.4%
Thick linear opacity	8	33.3%	8	33.8%
Centrilobular opacity	4	16.6%	6	23%
Mosaic attenuation pattern	8	16.6%	9	34.6%
Directly visible small airways (Most common)	*16*	*66.6%*	*19*	*73%*
Mucoid impaction	2	8.3%	4	15.3%

Table 7: Air Trapping on HRCT

	Mild disease		Moderate disease	
HRCT Finding	**No. of patients**	**Percentage of mild**	**No. of patients**	**Percentage of moderate**
Air trapping	3	12.5%	10	38.4%
Severity	No of patients	Percentage of total no. of pts. with air trapping	No of patients	Percentage of total no. of pts. with air trapping
Mild	*3*	*100%*	3	30%
Moderate	0	0	6	*60%*
Severe	0	0	1	10%

Table 8: Bronchiectasis on HRCT

	Mild disease		Moderate	
HRCT Finding	**No. of patients**	**Percentage of mild**	**No. of patients**	**Percentage of moderate**
Bronchiectasis	2	8.3%	5	19.2%
characteristic	No of patients	Percentage of total no. of pts. with Bronchiectasis	No of patients	Percentage of total no. of pts. with Bronchiectasis
Types				
Cylindrical	2		4	
Varicose	0	*100%*	1	*80%*
Cystic	O		0	
		0%		20%
		0%		0%
Lobar predominance				
Right upper lobe	0	0	0	0%
left upper lobe	0	0	0	0%
Right middle	0	0	1	20%
Left lingual	0	0	0	0%
Right lower	2	*100%*	4	*80%*
Left lower	0	0	0	0
Bronchiectasis location	0		1	
Segmental	0	0%	1	20%
Sub segmental	2	0%	3	20%
Distal		*100%*		*60%*

Table 9: Bronchial wall thickening on HRCT

	Mild disease		Moderate disease	
HRCT Finding	**No. of patients**	**Percentage of mild**	**No. of patients**	**Percentage of moderate**
Bronchial wall thickening	2	8.3%	9	34.6%
characteristic	No of patients	Percentage of total no. of pts. with Bronchial wall thickening	No of patients	Percentage of total no. of pts. with Bronchial wall thickening
Mild(1-2mm)	2	*100%*	7	*78%*
Moderate(2-3mm)	0		2	
Severe(>3mm)	0	0%	0	22%
		0%		0%

Emphysema will be visible in many conventional CT sections with thicknesses of 5 to 8 mm. However, it is more readily detected on high-resolution CT sections with thicknesses of 1 to 2 mm reconstructed with an edge enhancing algorithm. High resolution (HRCT) scanning is the method of choice for non invasive and sensitive assessment of pathologic changes in emphysema and has been shown to correlate well with pathologic grading.

In our study we found that *40% of* patients had emphysema on HRCT and separately *21%* of patients with mild disease and in *57%* of patients with moderate disease. 60% 0f emphysema patients with moderate disease had severe emphysema (>30%) while 80% of emphysema patients with mild disease had minimal emphysema (0-5%) and 0% had severe emphysema. The prevalence of severe emphysema increased from 0% to 60% from mild to moderate COPD. This increase in prevalence was statistically significant. Our study in this respect is in accordance with *Pescarolo et al.,* (2008) who in a study of 43 patients of COPD found a significant correlation between CT emphysema extent and GOLD stages. Our studies had near similar inclusion criteria's. Nawa *et al.,* (2002) reported a prevalence of 11.2% (686/6,144) in men of 50–69 years of age, including non-smokers examined with low-dose spiral CT. The prevalence of emphysema we found in mild disease is also close to those of 24% (16/67), 25% (20/80) and 34% (9/26) reported in smaller series of smokers who underwent thin slice sequential CT at standard dose and in whom emphysema was visually assessed and in a large study of lung cancer screening with low-dose CT in Spain in which a 29% prevalence of visually assessed emphysema was found in 1,166 former and current smokers of at least 40 years of age (Gianna *et al.,* 2009). Finally it matches the 26% prevalence found in a histological study. Centrilobular emphysema was the most common variety. However, we also observed panacinar emphysema in significant numbers, because as the process of centriacinar emphysema which advances the focal lesions becomes confluent, it may appear panacinar emphysema. All three types of emphysema had *upper lobe predominance*. Upper lobe predominance is seen in other studies like in a study by *Gupta et al.,* (2009) on High-resolution computed tomography features in patients with chronic obstructive pulmonary disease on 40 male patients with COPD and also in a study by *O'Brien et al.,* (2000) in 110 patients aged 40–80 years who had presented to their general practitioner with an acute exacerbation of COPD. Emphysema was confined to the upper lobes in most cases (73% of these patients).

Conclusion

To conclude, there are certain cardinal HRCT features of early cases of COPD that can be well-documented. During the last few decades, with the advent of high-resolution computed tomography

(HRCT), there has been increased interest in diagnosing emphysematous and chronic bronchitis components of COPD using HRCT. HRCT hence has a definite edge in the diagnosis of small airways disease. Directly observed airways is the most common HRCT finding in early cases. Various features of hyperinflation can also be well-identified over HRCT and the severity of COPD can be assessed authentically. It is possible on HRCT to identify the subtypes of emphysema. HRCT will be helpful in the management of COPD patients on an individual basis according to the disease subtype.

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