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Research Article

Role of high resolution computed tomography in evaluation of diffuse lung diseases

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ABSTRACT

Background: Diffuse lung diseases are those in which the disease process is widespread involving both the lungs but need not affect all lung regions uniformly. Plain chest radiograph though inexpensive, excellent modality of choice, the pattern of diffuse lung disease on radiography is often nonspecific. HRCT can detect normal and abnormal lung interstitium and morphological characteristics of both localized and diffuse lung diseases. The aims and objectives was to study the normal anatomy of the lung with respect to secondary pulmonary lobule; to evaluate the importance of high resolution computed tomography in the diagnosis of diffuse lung diseases; to detect diffuse lung diseases in patients who had normal or questionable radiographic abnormalities with symptoms or pulmonary function tests suggestive of diffuse lung disease; to determine the site of CT guided lung biopsy for confirmation of diagnosis in suspicious diseases and to study the various patterns of diffuse lung diseases on HRCT.
Methods: A total number of 50 patients with suspected or known interstitial lung disease were studied by high-resolution computed tomography (HRCT) over a period of 24 months.
Results: In the current study the most common cases are of tuberculosis. Next common condition observed was idiopathic pulmonary fibrosis,12 (24%) cases out of 50 cases and most of them were having changes of end stage lung disease and had short lived history during the course of this study, followed by bronchiectasis, pulmonary edema and emphysema.
Conclusions: HRCT is 16% more sensitive in detection of diffuse lung disease abnormalities than chest radiograph in our study.

Keywords: Diffuse lung diseases, Secondary pulmonary lobule, Lung interstitium, High resolution computed tomography

INTRODUCTION

Diffuse lung diseases are those in which the disease process is widespread involving both the lungs but need not affect all lung regions uniformly.[1] A large number of diseases cause diffuse infiltration of lung parenchyma and are therefore better described as "infiltrative lung diseases".[2] Pulmonary interstitium is the network of connective tissue fibers that supports the lung which includes interlobular septa, alveolar walls and the peri-bronchovascular interstitium.[3] Interstitial lung diseases are characterized by alveolar septal thickening, fibroblast proliferation, collagen deposition and if the process remains unchecked, it will lead to pulmonary fibrosis. The limitations of plain chest film in the assessment of lung disease especially diffuse lung disease and difficulties of characterizing lung morphology precisely became even more evident when computed tomography was introduced as a new tool in radiographic imaging. High resolution computed tomography (HRCT) was

introduced in 1985 by Zerhouni et al, the perfect imaging modality for characterization and diagnosis of diffuse lung diseases.[4] HRCT is a radiological imaging technique best suited for revealing changes in lung structure. Various HRCT findings taken together can represent typical patterns. These patterns in conjunction with clinical data, anatomical distribution can narrow the differential diagnosis of diffuse lung diseases. HRCT provides global anatomic assessment of the lung improving significantly specificity and sensitivity of the clinical diagnosis. HRCT can detect normal and abnormal lung interstitium and morphological characteristics of both localized and diffuse lung diseases. HRCT in combination with laboratory tests, physiological studies and invasive procedures proved to be a useful tool in reaching the differential diagnosis or final diagnosis. It differs from conventional CT by using thin collimation with high spatial frequency algorithm (bone algorithm). It has enabled imaging of the lung with excellent spatial resolution providing anatomical details similar to that available from gross pathologic specimens of lungs. In accordance with diffuse lung diseases HRCT plays major role in finding out as following; presence of disease in lung; type of disease; changes of active lung disease; site and type of biopsy to be performed; change in disease activity following treatment.

METHODS

A total number of 50 patients with suspected or known interstitial lung disease were studied by high-resolution computed tomography (HRCT) over a period of 24 months.

The study group consisted of 50 patients, of this 26 were males (52%) and 24 were females (48%). The age group of patients varied from 4 years to 75 years.

Selection criteria

Patients were selected on the basis of the following,

1. Clinical history suggestive of interstitial lung disease.
2. Known cases of interstitial lung disease.
3. Abnormal chest radiographs (with an interstitial pattern)
4. Abnormal restrictive pulmonary function tests.

Technique

The CT machine used was Siemens Somatom spirit dual slice CT scanner.

1. Patient was placed on gantry table in the supine position with both arms above the head and no gantry tilt.
2. A digitized AP scanogram was obtained in suspended full inspiration.
3. The patients were taught prior to procedures to hold breath in deep inspiration and expiration wherever required.
4. Axial sequencial scans of 1mm thickness were obtained at 10 mm intervals from lung apices to bases in suspended full inspiration.
5. Modifications in the above technique were done if indicated as; (1) prone scan were taken to determine whether opacities in the dependent lung are abnormal or not and (2) scans were also taken at the end of deep expiration to detect any air trapping.

Scanning parameters

Position : Supine
Scanner settings: KV(p): 120 – 140; mAs:129 – 150
Collimation : 1mm
Scan time : 1second.
Matrix size : 512 x 512
Superior extent : Lung apices.
Inferior extent : Domes of diaphragm.
Reconstruction : High spatial frequency algorithm.
Windows setting
Window width : 1200 to 1600 HU.
Window level : -600 to -800 HU.

RESULTS

Total 50 cases of diffuse lung disease were studied by high resolution computed tomography scanning of lungs in the department of radiology, Mamata medical college & hospital, Khammam, Telangana, India.

Age and sex

The age group in which maximum number of patients (10) presented was 41-50, 51-60 and 61-70 years each, which included 19 (63.3%) males and 11 (36.6%) females. Diffuse lung diseases are slightly more common in males than in females. Out of 50 cases 33(66%) were males and 17 (34%) are females (Table 1 and 2).

Table 1: Age and sex distribution of studied patients.

Age group (years)	Total no. of patients	Male		Female	
		No.	%	No.	%
<10	0	0		-	-
11-20	8	5	62.5	3	27.5
21-30	4	4	100	-	-
31-40	4	2	50	2	50
41-50	10	5	50	5	50
51-60	10	6	60	4	40
61-70	10	8	80	2	20
71-80	4	3	75	1	25
	50	33	66	17	34

Males are more in number in this study; 41 to 70 years age group people are more in number in this study.

Table 2: Diagnosis and sex wise distribution of cases.

Diagnosis	Total	Male		Female	
		No.	%	No.	%
Idiopathic pulmonary fibrosis	12	8	66.6	4	33.3
Tuberculosis	14	11	78.6	3	21.4
Bronchiectasis	10	6	60	4	40
Pulmonary edema	5	3	60	2	40
Emphysema	4	4	100	0	0
Scleroderma	2	-	0	2	100
Usual interstitial pneumonia	1	-	0	1	100
Desquamative interstitial pneumonia	1	1	100	-	0
Hematogenous metastases	1	-		1	100

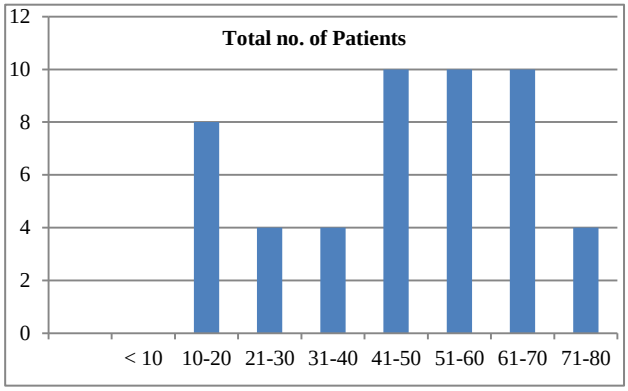


Figure 1: Case distribution according to age groups.

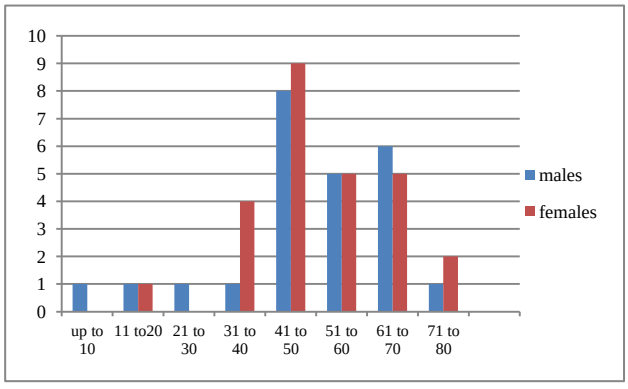


Figure 2: Case distributions according to age and sex.

Etiological diagnosis

In the current study the most common cases are of idiopathic pulmonary fibrosis. 14 (28%) out of 50 were observed during the course of this study out of which seven were new cases and seven were old cases. 4 cases of military tuberculosis were reported among the new cases. Next common condition observed was idiopathic pulmonary fibrosis, 12 (24%) cases out of 50 cases and most of them were having changes of end stage lung disease and had short lived history during the course of this study followed by bronchiectasis, pulmonary edema, emphysema (Table 3). Tuberculosis was most commonly observed in the age group of 51-60 and idiopathic pulmonary fibrosis was most commonly observed in the age group of 61-70 (Table 4).

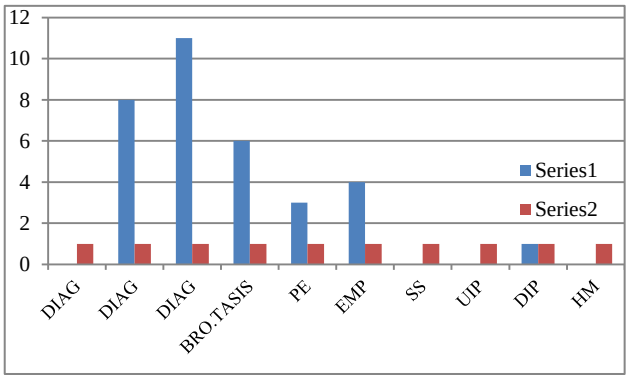
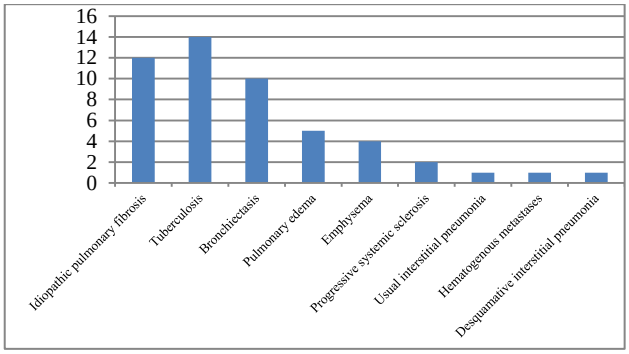


Figure 3: Sex distribution relation to diagnoses.

Table 3: Distribution of cases according to etiological diagnosis.

Diagnosis	No. of cases	Percentage (%)
Idiopathic pulmonary fibrosis	12	24
Tuberculosis	14	28
Bronchiectasis	10	20
Pulmonary edema	5	10
Emphysema	4	8
Progressive systemic sclerosis	2	4
Usual interstitial pneumonia	1	2
Hematogenous metastases	1	2
Desquamative interstitial pneumonia	1	2



Maximum numbers of cases in our study are of Tuberculosis.

Figure 4: Distribution of cases according to etiological diagnosis.

Clinical presentation

Out of 50 cases, 38 (76%) patients were primarily presented with dyspnoea. Most of them were of idiopathic pulmonary fibrosis and tuberculosis involving lungs. Rest of 12 (24%) patients were having varied symptoms like fever and cough. One patient of miliary TB seropositive for HIV.

Table 4: Distribution of cases according to age.

Disease	Total	<10	11-20	21-30	31-40	41-50	51-60	61-70	71-80
Tuberculosis	14	-	2	2	-	4	5	1	-
Idiopathic pulmonary fibrosis	12	-	-	-	1	1	1	5	4
Bronchiectasis	10	-	1	1	2	5	1	-	-
Pulmonary edema	5	-	1	1	-	-	-	3	-
Emphysema	4	-	1	-	1	-	-	2	-
Progressive systemic sclerosis (scleroderma)	2	-	2	-	-	-	-	-	-
Usual interstitial pneumonia	1	-	-	-	-	1	-	-	-
Hematogenous metastases	1	-	-	-	-	-	1	-	-
Desquamative interstitial pneumonia	1	-	-	-	-	-	-	1	-

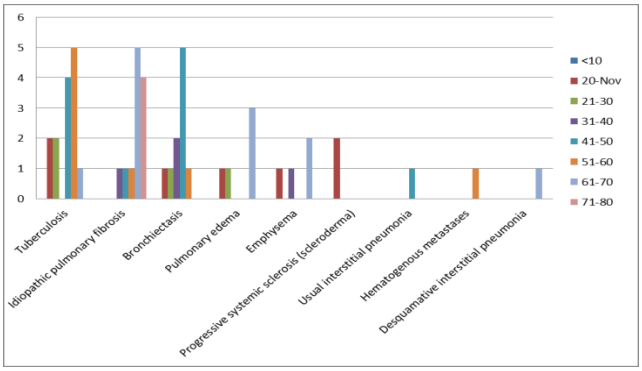


Figure 5: Age distribution according to diagnosis.

Location and morphology

Ground glass opacity (52%) was most commonly observed morphological finding followed by reticular (50%), bronchiectasis (40%) and honey combing (26%) (Table 5). The most common radiographic finding in idiopathic pulmonary fibrosis was of bilateral irregular linear opacities causing a reticular pattern and honeycombing. HRCT findings of IPF were predominant in peripheral, sub pleural regions, and in lung bases. Nodularity was commonly observed in miliary tuberculosis. Old cases of TB showed findings of broncho vascular distortion, bronchiectasis, fibrosis and cavities in all patients. Cases of active endobronchial disease in TB showed characteristic tree in bud appearance. The three pathological types of bronchiectasis were observed with predominance of cystic bronchiectasis. Patchy areas of ground-glass opacities with interlobular septal thickening which is smooth and uniform were the predominant findings observed in pulmonary oedema. Diffuse ground-glass opacity was observed in case of progressive systemic sclerosis (scleroderma) along with cysts. Centrilobular emphysema characterized by bilateral multiple, small centrilobular lucencies with ill-defined walls scattered throughout the lungs was observed and paraseptal emphysema was observed in the upper zone. Desquamative interstitial pneumonia (DIP) was observed as diffuse ground glass opacity in bilateral lung fields. Usual interstitial pneumonia (UIP) showed diffuse ground glass opacification with honeycomb pattern in bilateral lung fields. Hematogenous metastases to lung from an occult tumor showed multiple discrete nodules of varying sizes in bilateral lung fields with random distribution. Diffuse lung diseases are predominantly bilateral (Table 6).

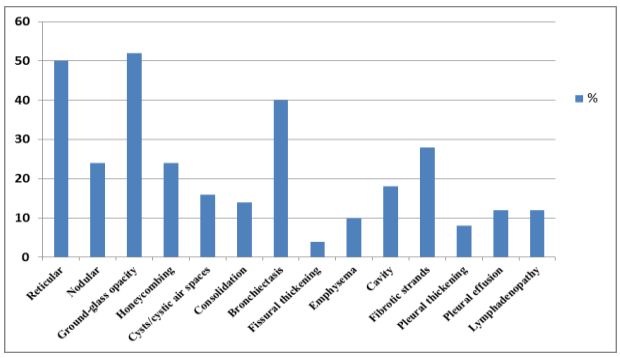


Figure 6: HRCT findings in diffuse lung diseases observed in 50 patients.

Table 5: HRCT findings in diffuse lung diseases observed in 50 patients.

HRCT Findings	IPF	TB	Bronchiecta	PE	Emphysema	S.S	DIP	HM	UIP
Reticular	12	8	1	2	-	2	-	-	-
Nodular	-	8	2	-	-	-	1	1	-
Ground-glass opacity	4	6	4	5	2	2	1	1	1
Honeycombing	10	-	1	-	-	-	-	-	1
Cysts/cystic air spaces	4	-	1	-	2	-	1	-	-
Consolidation	-	5	2	-	-	-	-	-	-
Bronchiectasis	8	-	10	-	-	1	-	-	1
Fissural thickening	--	2	-	-	-	-	-	-	-
Emphysema	1	-	-	-	4	-	-	-	-
Cavity	-	8	-	-	-	-	-	1	-
Fibrotic strands	4	7	2	-	-	-	-	-	1
Pleural thickening	-	4	-	-	-	-	-	-	-
Pleural effusion	-	4	-	2	-	-	-	-	-
Lymphadenopathy	-	2	2	-	1	-	1	-	-

Last three are associated findings.

Table 6: Distribution of fifty cases according to lung involvement.

Total Patients	Unilateral involvement	Bilateral involvement
50	4	46

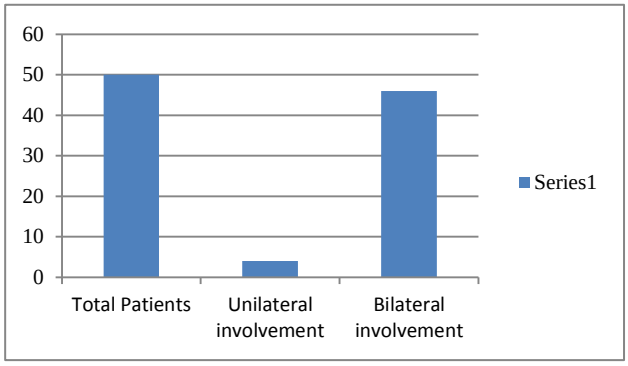


Figure 7: Distribution of fifty cases according to lung involvement.

Table 7: Sensitivity of HRCT compared to chest radiograph.

Total no of patients with normal chest radiography	8	16%
Total no of patients with abnormal chest radiography	42	84 %
Total no of patients with normal CXR and abnormal HRCT	8	16%
Total no of patients with abnormal CXR and abnormal HRCT	42	84%
Total no of patients abnormal CXR and normal HRCT	NIL	NIL

Eight cases which appeared normal on chest radiographs were detected as abnormal on HRCT whereas all cases abnormal on chest radiograph were also abnormal on HRCT. HRCT 16% more sensitive in detection of diffuse lung disease abnormalities than chest radiograph in my study.

DISCUSSION

A total number of 50 patients with suspected or known interstitial lung disease were studied by high resolution computed tomography (HRCT) over a period of 24 months. HRCT scans were done by obtaining 1 mm thick section at every 10mm intervals from thoracic inlet to diaphragm using high spatial frequency (bone) algorithm.

Tuberculosis

Study included fourteen (28%) cases of tuberculosis out of which seven were old patients with symptoms suggestive of reactivation of the disease. Cavities were seen in all 7 patients. Other findings such as pleural thickening were seen in 4 patients and mediastinal lymphadenopathy in 2 patients were described as explained by Im JG et al.[11]

Four of the seven new cases, diagnosed as military TB on HRCT showed randomly distributed nodules (1-3) mm commonly involving the perivascular and subpleural regions-consistent with findings of Hong SH et al and Voloudaki AE et al the remaining three cases showed tree in bud appearance consolidation, cavitation as described by Im JG et al.[11,20,21]

Idiopathic pulmonary fibrosis

In the present study we came across 12 cases of IPF. chest radiograph taken prior to CT of all the patients

showed reticular pattern in the lower zones and had probable diagnosis of ILD . On HRCT posterior basal and sub pleural areas were commonly affected in all patients (100%). Middle lobes and anterior segments of upper lobe involvement were seen in 4 patients suggesting disease process begins in posterior basal regions progressively involving the upper regions. These findings were correlated with findings of Lim MK et al and Battista G et al.[5,6]

Finding of honeycombing found as thick walled small air containing cystic spaces sharing walls and lying in the layers in posterior basal regions correspond to the findings of Nishiyama O et al.[7]

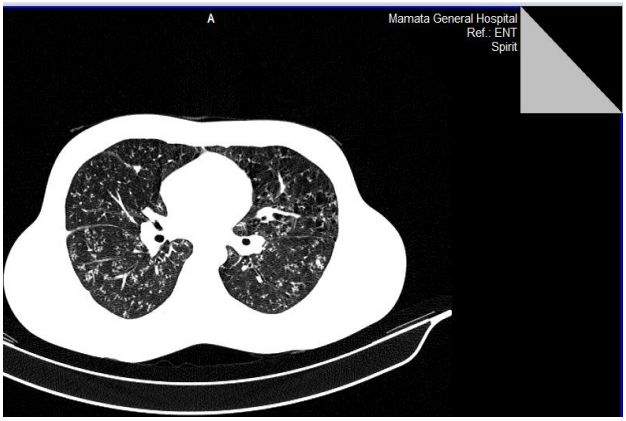
Intralobular interstitial thickening, irregular thickening of interlobular septa and traction bronchiectasis are some other findings noted in cases of IPF.

Bronchiectasis

It was detected in ten patients commonly affecting right middle lobe and left lower lobe in five patients each.lobar as well as segmental dilatation was possible in all patients as stated by by Cooke JS et al.[12] The characteristic signet ring appearance described by Grenier P et al was identified in 6 patients.[13] The three pathological types (cylindrical in four patients, varicose in two patients, cystic in six patients) described by Reid LM.[14]

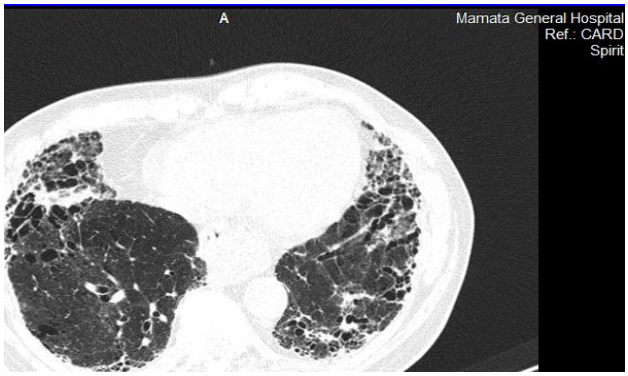
Pulmonary edema

Study included five (10%) case of pulmonary edema. Patchy areas of ground-glass opacities with interlobular septal thickening which is smooth and uniform were the predominant findings observed in these cases as reported by Storto ML et al and Ribeiro CM et al.[8,9]



HRCT findings: (A) Pattern of involvement: Multiple miliary nodular opacities are seen in both lung fields. Centrinodular opacities noted with tree in bud appearance in B/L lung fields. Illdefined nodular opacities are noted adjacent to major fissure in right lung. Radiological diagnosis**:** B/L miliary tuberculosis; Final diagnosis**:** B/L miliary tuberculosis.

Figure 8: Case of bilateral miliary tuberculosis.



HRCT findings: (A) Pattern of involvement: multiple areas of honeycombing noted in B/L lung fields predominantly in lower zones and peripherally. Patchy areas of ground glass opacities in both lung fields. Subpleural parenchymal bands are seen in both upper lobes and right lower lobe. Bronchiectatic changes are seen in both lower lobes. Emphysematous bullae left upper lobe. Interlobular septal thickening in B/L lung fields; (B) pleural involvement: B/L basal pleural thickening. Radiological diagnosis**:** Idiopathic pulmonary fibrosis**;** Final diagnosis**:** Idiopathic pulmonary fibrosis.

Figure 9: Case of idiopathic pulmonary fibrosis.

Emphysema

Study included four patients of emphysema of which three cases showed centrilobular emphysema characterised by bilateral multiple small centrilobular lucencies with ill-defined walls scattered through out the lungs in according to findings of Stern EJ and Frank MS, Webb WR et al and Murata K et al.[15-17]

Paraseptal emphysema was identified in one case.

Progressive systemic sclerosis (scleroderma)

Two (4%) case of scleroderma with lung involvement was included in this study. Diffuse ground-glass opacity was observed in these cases along with cysts representing changes of fibrosing alveolitis as described by Chan TY et al.[18]

Abnormalities were predominantly seen in subpleural regions and lower zone involvement as described by Chan TY et al, Devenyi K et al and JM Seely et al.[10,19]

Desquamative interstitial pneumonia

One case was reported which showed diffuse ground glass opacities in bilateral lung fields with apex to base gradient on HRCT. Subtle illdefined centrilobular nodules and cysts with few peripheral blebs seen along with few mildly enlarged precarinal lymph nodes. Chest X ray was found to be normal in this patient.

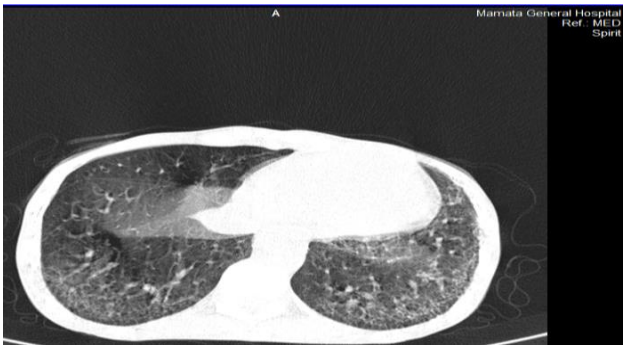
Usual interstitial pneumonia

One case of UIP with chest X ray diagnosis of bronchiectasis is included in the study. HRCT showed

diffuse bilateral ground glass opacification with honeycombing pattern. Extensive bronchiectatic changes noted in right middle lobe and left lower lobe.

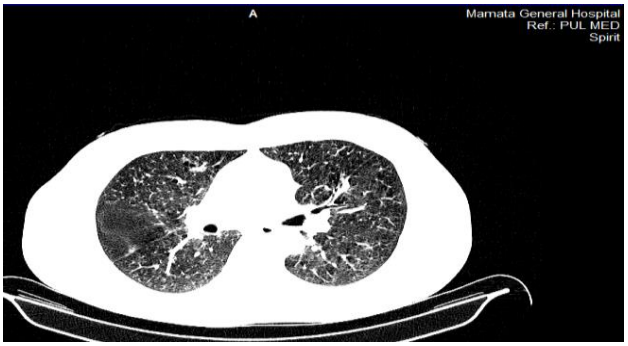
Hematogenous metastases to the lung

One patient (2%) with hematogenous metastases to the lung was included in the study. The patient had HRCT findings with multiple discrete nodules of varying sizes in bilateral lung fields with a random distribution.



HRCT findings: Pattern of involvement-Diffuse ground glass opacities seen bilaterally in lower lobe region posteriorly. Few areas of centrilobular emphysema observed predominantly in the ELFT lower lobe. Mild reticulation seen in bilateral lower zones. Radiological diagnosis: Early interstitial pneumonia involving B/L lower zones which could be secondary to systemic sclerosis; Final diagnosis: Systemic sclerosis.

Figure 10: Case of systemic sclerosis.



HRCT findings **:** Pattern of involvement -Diffuse ground glass opacity in bilateral lung fields with apex to base gradient. Subtle illdefined centrilobular nodules, few centrilobular cysts and few peripheral blebs seen on both sides; (a) Mediastinal lymphadenopathy- Few mildly enlarged precarinal lymph nodes noted. Radiological diagnosis**:** Changes of early desquamative interstitial pneumonia (DIP); Final diagnosis: DIP.

Figure 11: Case of desquamative interstitial pneumonia.

CONCLUSION

Eight cases which appeared normal on chest radiographs were detected as abnormal on HRCT whereas all cases abnormal on chest radiograph were also abnormal on HRCT. HRCT 16% more sensitive in detection of diffuse lung disease abnormalities than chest radiograph in our study. HRCT is the most accurate noninvasive imaging modality for evaluation of lung parenchyma. The cross sectional perspective and high spatial resolution makes HRCT superior to other imaging modalities like chest X-ray, lung tomography and conventional CT Scanning. Clinical evaluation, chest radiography and HRCT examination should be regarded as integral components of the investigation protocol in patients with various interstitial lung diseases. Hence high resolution computed tomography is a standard investigation to identify and quantify anatomic pattern and distribution of various interstitial lung diseases and also evaluates activeness and progression of disease in relation to prognosis and therapy.

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