Role of HRCT in Interstitial Lung Disease with Radiographic Correlation

Ankit Kumar Shah[1], Avadhesh Pratap Singh Kushwah[2], Sonjjoy Pandey[3], Shashi Prabha Tomar[4]

[1, 2, 3] Department of Radiodiagnosis, Netaji Subhash Chandra Bose Medical College, Jabalpur, Madhya Pradesh, India. [4]Department of Community Medicine, Netaji Subhash Chandra Bose Medical College, Jabalpur, Madhya Pradesh, India.

ABSTRACT

BACKGROUND

Diffuse interstitial lung disease is on the rise in recent times. This could be attributed to number of causes / reasons. Environmental pollution is one of the important causes for the upswing. Increased exposure to inorganic dust, toxic fumes, certain drugs (gold, amiodarone, antibiotics etc.) and radiation can also cause ILD (Interstitial Lung Disease).

METHODS

This is a hospital based prospective observational study, conducted in the Department of Radiodiagnosis, NSCB Medical College and Hospital, Jabalpur. This study comprised of a total of 50 patients clinically diagnosed interstitial lung disease who had undergone x-ray chest and HRCT (High-Resolution Computed Tomography) Chest examination.

RESULTS

Incidence of interstitial lung disease was maximum in the middle age group of 51 – 60 years (38 %) with male predominance (58 %). Smoking habit was seen to be associated with 52 % of the cases suggesting association. 8 patients (16 %) had developed diffuse lung disease secondary to connective tissue disorder (rheumatoid arthritis, progressive systemic sclerosis and polymyositis). A confident diagnosis was made on the basis of chest radiograph alone in 11 patients (29 %). Among cases evaluated by HRCT Chest, 41 (82 %) cases showed specific patterns of ILD and nine cases (18 %) showed nonspecific patterns and were classified under unclassified IIP (Idiopathic Interstitial Pneumonia). Out of 41 cases, the most common ILD reported was IPF (20) followed by cases of idiopathic NSI, 8 cases of collagen vascular diseases, 2 cases suggestive of COP / BOOP, and smoking related ILDs were seen in 4 cases, and 2 cases of sarcoidosis were seen in the study. Occupational- and radiation-induced-ILD were seen in one case each.

CONCLUSIONS

Chest radiography is the initial imaging investigation in the evaluation of diffuse interstitial lung disease. HRCT is the imaging modality of choice to assess interstitial lung disease. It can detect lesion even when the chest radiograph is normal. HRCT can confirm the location, extent of disease, and pattern of disease. HRCT helps in the confident diagnosis of ILD as compared to chest radiography. Thus, it avoids lung biopsy in a large number of patients. HRCT is also useful in assessing the disease reversibility. Follow up of patients is better done by HRCT.

KEYWORDS

HRCT, Interstitial Lung Disease, Chest X-Ray, Ground Glass Opacity, Honeycombing

Corresponding Author:
Dr. Shashi Prabha Tomar,
Plot 137, Jasuja – City Phase 2,
Dhanvantree Nagar, Jabalpur,
Madhya Pradesh, India.
E-mail: tomarshashi9@gmail.com

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BACKGROUND

Diffuse interstitial lung disease represents a large number of conditions that involve parenchyma of lung, the alveoli, the alveolar epithelium, the capillary endothelium and the spaces between these structures, as well as perivascular and lymphatic tissues.

The cases of ILD are on the rise in recent times. This could be attributed to number of causes / reasons. Environmental pollution is one of the important causes for the upswing. Increased amount of exposure to inorganic dust and toxic fume causes inflammation in the air space and alveolar wall. If the exposure is chronic, interstitial and vasculature are involved eventually, causing fibrosis. Exposure to organic dust results in condition of hypersensitivity pneumonitis. Certain drugs (gold, amiodarone, antibiotics etc) and radiation can also cause ILD. Besides these, there are many unknown causes of ILD contributing to majority of the cases, associated with considerable mortality and morbidity. So it is important to detect these diseases early, so that progression of the disease can be stymied.[1]

The non-invasive diagnosis of ILD was considered to be insecure before the advent of CT. Most of Clinical diagnostic criteria (bilateral crackles, chest radiographic findings compatible with bilateral fibrosis and restrictive pattern of lung function test) were necessarily non-specific; and this had leaded some of the clinicians to advise routine open lung biopsy in patients with suspected ILD. The only radiographic tool available was Chest radiography at dispersal with poor sensitivity and detecting disease at rather advanced stage of disease, as a result many patients had to undergo open lung biopsy for diagnosis of ILD.

Chest radiography does not discriminate between inflammatory and fibrotic disease.[2]

By using thin section in HRCT one can diagnose ILD in its early stage even when chest radiography is normal. The use of HRCT is not just confined to the diagnosis of ILD but also plays a key role in the non-invasive evaluation of disease activity in ILD. The separation of patients into usual interstitial pneumonitis and desquamative interstitial pneumonitis has been a consistent predictor of outcome before CT scan guided open lung biopsy was the sole reliable means of predicting survival and responsiveness to treatment.[3]

For predicting responsiveness to treatment HRCT patterns are considered as accurate as histological appearance. Predominance of ground glass attenuation usually represents inflammatory cell infiltration and may responds to treatment. However, when it is admixed with an equally extensive reticular pattern, often reflects a poor prognosis.[4]

METHODS

The hospital based prospective observational study was conducted on 50 patients, who were referred to the Radio diagnosis Department of NSCB (Netaji Subhash Chandra Bose) Medical College and Hospital in conjunction with MRI and CT scan centre Jabalpur (MP) from January 2018 to August 2019. All the patients of whom with strong clinical suspicion of interstitial lung disease during this study period and fulfilling inclusion criteria were included in our sample thus sample size comes out to be 50. All patients included in study were of age > 30 years and have undergone chest x-ray and HRCT chest Scan with strong clinical suspicion of interstitial lung disease.

Permission from the Institutional Ethical Committee was obtained prior to the study and informed consent of study subjects was taken before HRCT chest was done.

Exclusion Criteria

- Cases that have undergone either HRCT or chest radiographs alone were excluded.
- Uncooperative patients.

Chest Radiograph

All the radiographs were carried out on RMS (500 mAs) Computed Radiograph System and ProRad 3NC Digital Radiograph System in standard erect position and in full inspiration in PA view. 60 - 80 KVP and 15 - 20 mAs were used with a film focus distance of 180 cm. High resolution computed tomography of lung.

HRCT Chest

Imaging Protocol

HRCT was performed on the multislice CT machine (GE OPTIMA 660 16 SLICE)

- HRCT of lung was performed using helical CT scan technique with the following technical parameters.
- Scan collimation best visualisation of fine details of small vessels, bronchi & interlobular septa was achieved with 1 - 1.5 mm collimation.
- Reconstruction algorithm–high spatial frequency reconstruction algorithm was used to sharpen the image definition by reducing image smoothing.
- Slice thickness-thinnest available (0.5 - 1.5 mm).
- Scan time is kept shortest i.e. 1 sec or less.
- 120 – 140 KVP.
- 100 - 200 mA–High KVP & mA was taken to decrease the image noise, for the same reason scan time was also kept short.
- Matrix size was taken largest available (512 x 512).
- Window W-1500 L-600.
- Patient position was usually supine but, prone scans were obtained wherever needed.
- Respiratory level–routine HRCT was obtained during suspended full inspiration. However when air trapping was suspected, expiratory image were also taken.

Imaging Criteria

The presence of diffuse lung disease was suspected on chest radiography in the presence of following features

1. Reticular opacities
2. Septal lines

3. Nodular Opacities
4. Honeycombing
5. Areas of volumes loss.
6. Altered areas of lung density e.g., ground glass opacity, emphysematous changes and consolidation.
7. An additional feature of pleural effusion and lymphadenopathy.

On HRCT, the Interstitial Lung Disease was Diagnosed by These Findings

1. Linear reticular opacities,
2. Nodular opacities,
3. Honeycombing,
4. Ground glass opacities,
5. Traction bronchiectasis,
6. Interlobular and intralobular septal thickening,
7. Areas of fibrosis,
8. Volume loss.
9. Consolidation

Statistical Analysis

Data collected was transferred in an excel sheet to calculate the percentage and proportions and to find statistical significance chi square test was applied wherever necessary. A p value of <.05 was taken as significant.

RESULTS

Age Group	Number of Cases (n = 50)	%
30 – 40	6	12 %
41 – 50	12	24 %
51 – 60	19	38 %
61 – 70	8	16 %
71 – 80	4	8 %
81 – 90	1	2 %

Table 1. Age Wise Incidence of ILD

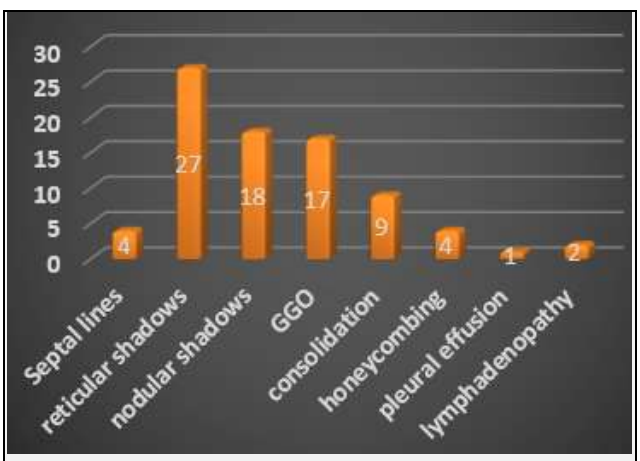


Figure 1. Abnormal Findings on Chest Radiograph

Findings	Number of Case (n = 50)	%
Reticular / Linear Striations	40	80 %
Nodules	30	60 %
Ground Glass Opacity	22	44 %
Consolidation	14	28 %
Interlobular Septal Thickening	36	72 %
Honeycombing	23	46 %
Traction Bronchiectasis	20	40 %

Table 2. Abnormal Findings on HRCT

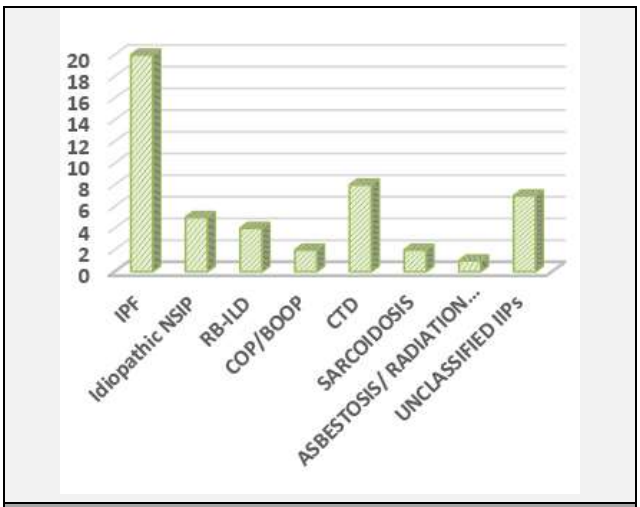


Figure 2. Distribution of Diseases Studied with HRCT Chest

Reticular Opacity	HRCT n	HRCT %	X Ray n	X Ray %	Total	X^2	p Value
Present	40	80	27	54	67	7.6436	0.005697
Absent	10	20	23	46	33		
Nodular Opacity							
Present	30	60	18	36	38	5.7692	0.0163
Absent	20	40	32	64	62		
Ground Glass Opacity							
Present	22	44	17	34	39	1.0509	.3053
Absent	28	56	33	66	61		
Honeycombing							
Present	23	46	4	8	27	18.3156	0.000019
Absent	27	54	46	92	73		

Table 3. Abnormal Findings in HRCT Chest and Chest Radiograph

The result are significant at $p < 0.05$

The study involves 50 patients of suspected interstitial lung diseases that have been addressed from the various departments of NSCB Medical College and Hospital, Jabalpur.

In this study, cases reported were of 30 to 90 yrs. among which highest incidence of disease was observed in the age group of 51 – 60 yrs. and minimum amongst age group of 81 - 90 yrs. Males were more commonly effected than female and 52 % of all cases were smokers. 24 % of cases showed normal chest radiograph while the remaining 38 patients (76 %) did have positive findings.

In 52 % of patient's predominant lower zone involvement including patients of fibrosing alveolitis, rheumatoid arthritis and idiopathic pulmonary fibrosis were found while 39 % had both upper and lower zone without any marked predilection.

Only 3 patients (7.8 %) had predominant upper lung involvement among which, two patients were of sarcoidosis, and one was of rheumatoid arthritis. HRCT, the most common findings are the reticular striations where it managed to detect in 80 % of the cases.

DISCUSSION

The study was conducted among 50 patients of suspected interstitial lung disease who had been referred from various departments of NSCB Medical College and Hospital, Jabalpur.

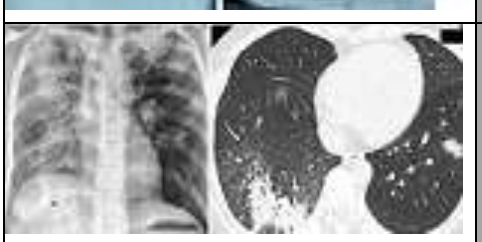
	***Idiopathic Pulmonary Fibrosis***
	***UIP Pattern: Progressive Systemic Sclerosis patient***
	***UIP Pattern of interstitial Lung Disease***
	***Respiratory Bronchiolitis***
	***Disease in Rheumatoid arthritis patient***
	***e4-NSIP patterns of Interstitial***
	***Cryptogenic organizing Pneumonia figure***

Figure 3

In this study, around 78 % of cases recorded were in the age group of 41 to 70 yrs. among which highest incidence was observed in the age group of 51 – 60 yrs. According to the Muller et al (1991)[5] also, the highest incidence of diffuse lung diseases is in the age group of 41 – 70 yrs. Diffuse lung diseases are rare in children and adolescents[2]

In this study, 58 % of patients were male and 42 % were female. The high incidence among males can be attributed to more chances of their exposure to environmental and industrial pollutants since they are thought to be the bread earners in our society. So, there is male predominance, which is in accordance with the studies by Muller et al (1991).[5]

Smoking habits were found in 52 % of patients in our series and 48 % were non-smokers.

According to the Muller et al,[5] nearly all connective tissue disorders can affect the lung. Our study also showed a slight correlation with interstitial lung disease i.e. 8 cases (16 %) were suffering from connective tissue disorders - 5 had rheumatoid arthritis, 2 had systemic sclerosis (scleroderma) and 1 with Sjogren's disorder.

Plain Chest Radiography

In this study, we found that 12 patients (24 %) showed normal chest radiograph while the remaining 38 patients (76 %) did have positive findings.

In the present study, following radiographic findings were encountered (n = 38):

- Septal lines (10.5 %)
- Reticular shadows (71 %)
- Nodular or reticulonodular shadows (47 %)
- Ground glass opacities (44 %)
- Consolidation (23 %)
- Honeycombing (10.5 %)
- Pleural effusion (2 %)
- Lymphadenopathy (5 %).

The above-mentioned findings are constant with the radiographic findings described by Muller et al.[5]

Findings of chest radiography were divided into predominantly upper zone involvement, lower zone involvement or diffuse distribution involving both.

According to a study conducted by JR Mathieson et al,[6] accounting 118 patients of chronic diffuse lung disease, definite diagnosis was possible in 23 % of cases with positive radiographic findings.

While In our study, confirmatory diagnosis was made in 11 patients (22 %) on radiographic appearance of chest X-Ray.

HRCT and Chest Radiograph Correlation

All cases in our study were subjected to HRCT and following findings were observed:

- Reticular / linear striations (80 %)
- Nodules (60 %)
- Ground glass opacity (44 %)
- Consolidation (28 %)
- Interlobular septal thickening (72 %)
- Honeycombing (46 %)
- Traction bronchiectasis (40 %)

Here, in HRCT, the most common findings are the reticular striations where it managed to detect in 80 % of the cases. The chest radiographs also showed reticular opacities as the most common abnormality observed in 67 % of the cases, thereby implying a much greater sensitivity in the identification of these densities by HRCT with

statistically significant differences. Furthermore, in the detection of these reticular opacities, although conventional chest radiography was able to differentiate between medium and coarse opacities, their detection of fine reticular densities was a cause of concern. Whereas, HRCT was effective in detecting fine reticular opacities in the lungs when the chest radiograph revealed no such abnormalities. Zerhouni et al[7] also said that reticular striations were found in 89 % of cases in a series. The reticular pattern is associated with a large group of interstitial lung diseases including UIP (Usual Interstitial pneumonia), DIP (Desquamative Interstitial Pneumonia), AIP (Acute Interstitial Pneumonia), NSIP (Nonspecific Interstitial Pneumonia), IPF (Idiopathic Pulmonary Fibrosis), collagen vascular disease, drug induced lung disease, radiation pneumonitis and fibrosis and asbestosis.[8]

Nodular opacities are another very common manifestation of interstitial lung diseases. In our study, 36 % had nodular opacities in their chest radiographs while HRCT showed evidence of nodular opacities in 60 % of the cases with statistically significant difference. The appearance of the nodules themselves can be an indicator as to whether they are interstitial or air space nodules. Interstitial nodules tend to be sharply marginated while air space nodules poorly defined.

This distinction of nodules is much better appreciated on HRCT scans than on chest radiograms. Furthermore, the location and distribution of nodules in relation to lung structures is a key determinant in narrowing down the differential diagnosis. Nodules can be classified as perilymphatic, random and centrilobular based on their distribution on HRCT. Perilymphatic nodules occur in relation to lung lymphatics and in clinical practice are usually the result of sarcoidosis. In our study, this perilymphatic distribution of nodules in sarcoidosis was well appreciated. Such narrowing down of the differential diagnosis based on the nodule distribution was possible only on HRCT and not on chest radiography.

Sumikawa H, et al in 2005[9] found that the frequency of occurrence of small nodular opacities in HRCT scans were significantly higher than those seen in radiography in all lung zones ($p < 0.01$). For detection of small opacities of mid zones of the lung HRCT was more sensitive than radiography, but no statistical significance of the same was found for the two methods in the detection of small opacities of lower zones of the lung. More detectability of bulla, emphysema, pleural, mediastinal and hilar changes was observed as reflected by statistically significant increase detection. ($P < 0.05$).

In our study, 72 % of patients showed septal thickening. The next most common finding is the presence of interlobular septal thickening. Normal interlobular septum marginates part of a secondary pulmonary lobule and contains pulmonary vein and lymphatics. These septae measure approximately 0.1 mm in thickness and are occasionally seen on normal HRCT scans. Their presence on HRCT always indicates their thickening. Early sign of fibrosis in many of lung diseases is thickening of interlobular septa.

Honeycombing is present in a significantly large number of cases in our study. The end stage of interstitial lung disease is characterized by honeycombing. It reflects extensive lung fibrosis with alveolar destruction, thereby, resulting in a characteristic reticular appearance. On HRCT, it is associated with gross distortion of lung architecture, where individual lobules are no longer visible. In our study, such honeycombing was seen in 46 % of the cases on HRCT while chest radiography could detect them in only 27 %. On HRCT, honeycombing was much more accurately diagnosed by the presence of thick walled, air filled cysts, usually measuring 3 mm to 1 cm in diameter, typically occurring in several layers at the pleural surface. Detection of honeycombing has a great clinical significance as its presence strongly suggests the diagnosis of usual interstitial pneumonia. It also indicates end stage disease, whereby the patient will gain little from a lung biopsy and hence avoided. In this context also, HRCT definitely scores over conventional radiography. According to studies by Staples CA et al[10], honeycombing is present in around 50 % of cases of IPF, where it is predominantly basal and peripheral.

Ground glass opacity and consolidation were demonstrated in 44 % and 28 % respectively, of all the patients in our study while chest radiography could detect 39 % and 18 % of cases. Ground glass opacity is a common but non-specific finding on HRCT, reflecting the abnormalities below the limit of CT resolution. In a study by Leung AN et al,[11] the pattern was shown to be caused by predominantly interstitial disease in 54 % of cases. It is commonly seen in acute or subacute stage of extrinsic allergic alveolitis, (Respiratory Bronchiolitis) RB-ILD, DIP and pulmonary alveolar proteinosis. In a study by Hartmen TE et al,[12] taking into account 22 patients with DIP, all patients had ground glass opacity with a predominantly basal and peripheral distribution.

Traction bronchiectasis is present in a significant number of patients (40 %) in our study. According to Webb, Muller & Naidich,[13] bronchial dilatation and irregularity occurs in patients who have pulmonary fibrosis due to tractions exerted by fibrous tissue on the bronchial wall.

HRCT Pattern and Disease Spectrum of Interstitial Lung Diseases

0ut of 50 cases in our study, specific patterns of ILD was seen in 43 (86 %) of cases and seven cases (14 %) showed nonspecific patterns which were classified under unclassified IIP. We found that the most common interstitial lung disease reported on HRCT was idiopathic pulmonary fibrosis 20 (40 %) i.e., UIP pattern with idiopathic cause.

Smoking related ILDs (RB-ILD and DIP) were reported clinic-radiologically in 4 (8 %) of the total cases studied with the positive history of smoking.

Five (10 %) cases with serologically positive rheumatoid arthritis were reported in our study. Most common pattern found with rheumatoid arthritis was reticular opacity associated with UIP pattern. Cryptogenic organizing

pneumonia has been reported in two of the total cases studied.

Out of the two cases of progressive systemic sclerosis, one case indicated NSIP pattern and the other UIP pattern with preserved lung volume. In our study, the diagnosis of interstitial lung diseases was suggested in almost all 100 % cases by HRCT.

The average sensitivity results of several studies[8], HRCT have sensitivity of approximately 94 % compared to the chest radiography which has 80 %. The inference that can be drawn from this study is that HRCT is much more sensitive than that of conventional chest radiography for assessing and diagnosing the patients with interstitial lung diseases. Hence, HRCT seems to be the investigation of choice for the evaluation of the parenchymal abnormalities in interstitial lung disease.

CONCLUSIONS

Interstitial lung disease mainly affects middle age group and shows male predominance. Smoking is related to the causation of diffuse interstitial lung diseases. It is also associated with various types of connective tissue disorders.

Chest radiography is the initial imaging investigation in the evaluation of diffuse interstitial lung disease. It is helpful in assessing the pattern of lung disease i.e. reticular or nodular; and accompanying abnormalities like lymphadenopathy, pleural effusion, cardiomegaly etc. But it has several limitations like obscured or hidden lung zones, limited contrast resolution which impairs sensitivity to subtle alteration in lung density (e.g., ground glass attenuation).

Confident diagnosis of interstitial lung diseases by radiograph alone is made in a small proportion of cases, and a normal chest radiograph does not rule out the possibility of ILD.

HRCT is the imaging modality of choice to assess interstitial lung disease. It can detect lesion even when the chest radiograph is normal. HRCT can confirm the location, extent of disease and can further characterise the location, and pattern of disease.

HRCT helps in confident diagnosis of ILD as compared to chest radiography. Thus, it avoids lung biopsy in a large number of patients.

HRCT is also useful in assessing the disease reversibility. Follow up of patients is better done by HRCT. Frequent biopsies are not feasible to know the course of disease and chest radiograph is not adequate for follow up.

Therefore, HRCT is essential for the diagnosis, management and follow–up of the cases of diffuse lung disease.

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