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Original Article

Role of High-Resolution CT Thorax in Interstitial Lung Disease Evaluation

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Abstract

Background: High-Resolution Computed Tomography (HRCT) plays a crucial role in the evaluation of interstitial lung diseases, offering detailed imaging for accurate diagnosis.

Objective: To evaluate diagnostic precision and clinical relevance of HRCT in evaluating Interstitial Lung Diseases (ILDs).

Methods: This observational study analyzed HRCT images from 30 patients using a multi-detector CT scanner. The study was conducted at the Department of Radiodiagnosis of Gian Sagar Medical College and Hospital, India, in a period of one year (January 2024 to December 2024). Images were reviewed by two radiologists for various features, including ground-glass opacities, reticulations, honeycombing, and traction bronchiectasis. The patterns were classified as definite UIP, probable UIP, or suggestive of chronic HP or NSIP.

Results: Eighteen patients (60%) showed basal-predominant honeycombing, reticulations, and traction bronchiectasis consistent with definite UIP. Six of these also exhibited upper lobar emphysema, categorized as Combined Pulmonary Emphysema and Fibrosis (CPFE). Another six patients with NSIP displayed subpleural curvilinear opacities, fine reticulations, and ground-glass abnormalities. Six (20%) patients with chronic HP showed diffuse ground-glass opacities and traction bronchiectasis, primarily in the upper lobes with air trapping on expiratory scans.

Conclusion: This case series demonstrates the diverse HRCT findings in ILD, underscoring the importance of HRCT in diagnosis and prognosis. Larger studies with histopathological confirmations are needed to refine these diagnostic insights.

Keywords: HRCT, hypersensitivity pneumonitis, interstitial lung disease, NSIP, usual interstitial pneumonia

Introduction

Interstitial lung diseases (ILDs) represent a broad and heterogeneous group of pulmonary disorders. These disorders are marked by varying degrees of inflammation, fibrosis as well as distortion of the lung's interstitial architecture.[1] This vast spectrum includes conditions associated with autoimmune reactions, environmental exposures and drug-induced toxicity. Idiopathic cases, where no attributable cause can be identified, are also common. The complexity of ILDs is compounded by their overlapping clinical presentations and radiological features. These overlapping clinical features make precise diagnosis and appropriate management a significant clinical challenge.[2] High-resolution

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computed tomography (HRCT) of the thorax is increasingly becoming an indispensable imaging modality in the assessment of cases of ILD. It provides details of lung parenchyma that are critical for the accurate assessment of these diseases.[3]

HRCT provides detailed images of the lung tissue by using thin-section imaging and have high spatial resolution reconstructions which allow identification of subtle parenchymal abnormalities. HRCT demonstrates key radiological features such as ground-glass opacities, reticulations, honeycombing, and architectural distortion in great detail.[4] These findings are important in distinguishing different ILD subtypes. For instance, the presence of peripheral, subpleural reticulations with honeycombing is highly suggestive of idiopathic pulmonary fibrosis (IPF) whereas a more diffuse pattern of ground-glass opacities may point toward non-specific interstitial pneumonia (NSIP) or hypersensitivity pneumonitis (HP).[5] Such precise imaging not only narrows the differential diagnosis but also directs the subsequent need for invasive procedures such as lung biopsies when the clinical picture remains ambiguous.[6]

Moreover, HRCT plays a critical role beyond mere diagnosis. It provides baseline data of disease severity and extent facilitating the assessment of progression of disease over time.[7] Serial HRCT scans can help treating physician evaluate the effectiveness of therapeutic interventions thereby guiding modifications in management strategies.[8] This aspect is important in ILDs where the progression from inflammation to irreversible fibrosis can significantly alter patient outcomes. The ability of HRCT to capture even minute changes in the lung architecture makes it an essential tool in patient management.[9]

The integration of HRCT findings with clinical and histopathological data is important for comprehensive management of ILDs.[10] HRCT not only assists in differential diagnosis but also can be used in monitoring disease progression and evaluating treatment response.

While HRCT offers assessment of severity of the disease process, histopathological examination provides definitive tissue characterization. Histopathology also helps in differentiating between various ILD subtypes and helps in identifying coexistent pathologies such as inflammation, fibrosis, or granulomatous changes. Histopathology also remains the gold standard for accurate diagnosis particularly in cases where HRCT findings are inconclusive or overlap between patterns.[11] This multidisciplinary approach ensures that patients receive individualized management.

The present study examines diverse HRCT patterns observed in ILDs, including IPF, NSIP, and HP. By analyzing these imaging characteristics, the study aims to highlight the diagnostic precision and clinical relevance of HRCT in the evaluation and management of ILDs.

Methods

This prospective observational study was conducted in the Department of Radiology at Gian Sagar Medical College and Hospital, Rajpura, Patiala, India, with the aim of evaluating the spectrum of high-resolution computed tomography (HRCT) thorax findings in patients with interstitial lung diseases (ILDs). The study was designed to assess HRCT imaging characteristics and correlate them with clinical and functional parameters. The study duration was one year, from January 2024 to December 2024. Since it was a purely observational study where CT images were analyzed (and no ethical issues were involved) hence ethical clearance was waivered. A total of 30 patients clinically suspected of having ILDs and referred for HRCT thorax as part of their diagnostic evaluation were included. The diagnosis of ILDs was established through a multidisciplinary approach, incorporating clinical evaluation, laboratory investigations and imaging findings. Patients with incomplete imaging or clinical data and those with poor-quality CT scans due to motion artifacts were excluded from the study.

The sample size was calculated based on a pilot study evaluating the prevalence of ILD patterns on HRCT. Using OpenEpi software (version 3) and assuming a 95% confidence interval and 90% power, the minimum required sample size was estimated to be 27 patients. To account for potential dropouts or exclusions due to incomplete data, a final sample of 30 patients was included in the study.

Demographic and clinical data—including age, sex, and comorbidities—were recorded at the time of enrollment. The HRCT findings were correlated with clinical and functional data to evaluate disease severity and distribution. HRCT scans were performed using a multi-detector CT scanner (Somatom go. UP, Siemens, Munich, Germany) with patients positioned supine during full inspiration. Non-contrast

HRCT imaging was conducted to assess lung parenchyma. Thin-section images (1 mm slice thickness) were obtained and reconstructed in axial, coronal, and sagittal planes using a high spatial resolution algorithm. The standardized scan parameters included a tube voltage of 130 kVp, an auto-adjusted tube current based on patient body habitus, collimation of 32 × 0.7 mm, and a reconstruction kernel optimized for lung parenchyma. The matrix size was set at 512 × 512 to ensure high-resolution imaging.

HRCT images were independently reviewed in real time by two experienced radiologists. The following imaging features were systematically assessed: ground-glass opacities, mosaic attenuation, reticulations, honeycombing, emphysema, and traction bronchiectasis. In instances of disagreement between radiologists a consensus was reached through joint discussion. However, formal statistical analysis of interobserver agreement was not performed at the time of data analysis.

Based on imaging characteristics, cases were categorized as definite usual interstitial pneumonia (UIP), probable UIP, or suggestive of alternative diagnoses such as chronic hypersensitivity pneumonitis (HP) or nonspecific interstitial pneumonia (NSIP). The extent of parenchymal involvement was visually assessed and categorized as mild (<25%), moderate (25–50%), or severe (>50%). The distribution pattern of lung involvement was also documented in terms of zonal predominance (upper, middle, or lower lobes) and axial distribution (central, peripheral/subpleural, or diffuse).

Data were recorded in Microsoft Excel and analyzed using SPSS software (version 23.0). Quantitative variables, such as age and percentage of lung involvement, were expressed as mean ± standard deviation (SD). Categorical variables, including specific HRCT patterns and distribution features, were reported as frequencies and percentages. A p-value of <0.05 was considered statistically significant.

Results

Among the 30 patients included in the study, 19 (63.33%) were male and 11 (36.67%) were female, yielding a male-to-female ratio of 1:0.57. The analysis of the age distribution among the studied cases showed that the most common age group was 51–60 years, comprising 30.0% of the total patients (31.6% of males and 27.3% of females). This was followed by the 61–70 years age group, accounting for 26.7% of all patients (26.3% of males and 27.3% of females). The 41-50 years category made up 20.0% of cases, while patients aged 71 years and above constituted 13.3%. The least common group was 19-40 years, contributing only 10.0% of the total cases. The mean age of male patients was 59.1 ± 9.8 years, while for females, it was 56.8 ± 11.2 years, with an overall mean age of 57.95 ± 10.5 years. The p-value for age distribution was 0.561, indicating that the difference in age between males and females was not statistically significant (Table 1).

The analysis of the HRCT patterns in studied cases revealed that reticulations were present in all cases (100 %), followed closely by traction bronchiectasis, which was observed in 24 patients (80%). Honeycombing was noted in 24 cases (80 %) as well, while ground-glass opacities (GGO) were seen in 12 patients (40 %). Air trapping and emphysema were seen in 6 (20 %) cases. The CT images were analyzed for presence of UIP, NSIP and Chronic HP patterns.

HRCT Thorax of 18 patients (60%) demonstrated basal-predominant

Table 1 Gender-wise Distribution of Studied Cases by Age Group

Age Group	Males (n)	Males (%)	Females (n)	Females (%)	Total Patients	Total (%)	p-value
19–40 years	2	10.5	1	9.1	3	10	
41–50 years	4	21.1	2	18.2	6	20	
51–60 years	6	31.6	3	27.3	9	30	
61–70 years	5	26.3	3	27.3	8	26.7	0.561
71+ years	2	10.5	2	18.2	4	13.3	
Total	19	100	11	100	30	100	
Mean Age	59.1 ± 9.8 years		56.8 ± 11.2 years		57.95 ± 10.5 years		

Table 2 HRCT Patterns Observed in Studied Cases (n = 30)

HRCT Pattern	Present		Absent		Total	
	Number of cases	Percentage (%)	Number of cases	Percentage (%)	Number of cases	Percentage (%)
Honeycombing	24	80	6	20	30	100
Reticulations	30	100	0	0	30	100
Traction Bronchiectasis	24	80	6	20	30	100
GGO	12	40	18	60	30	100
Air Trapping	6	20	24	80	30	100
Emphysema	6	20	24	80	30	100

Table 3 Severity of Lung Parenchymal Involvement on HRCT (n=30)

Severity of Involvement	Number of cases	Percentage (%)
Mild (< 25)	6	20
Moderate (25–50)	12	40
Severe (>50)	12	40
Total	30	100

honeycombing of various degrees. This was accompanied by fine reticulations and traction bronchiectasis. In 6 of these cases (20%), more than 50% of the lung parenchyma was affected, while the remaining 12 cases (40%) exhibited 25–50% involvement. Among these UIP cases, 5 patients (16.7%) also demonstrated upper lobe-predominant paraseptal emphysema, consistent with combined pulmonary fibrosis and emphysema (CPFE). NSIP-like changes were observed in 6 patients (20%), showing subpleural curvilinear opacities, bilateral

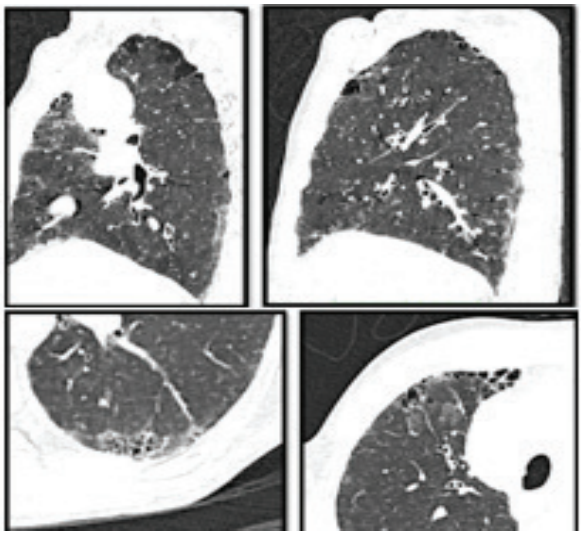

Fig. 1 Combined Pulmonary Fibrosis and Emphysema (CPFE)
Sagittal HRCT images demonstrate apical paraseptal emphysema and basal predominant fibrosis. Axial images in lung window reveal subpleural areas of honeycombing and fine reticulations

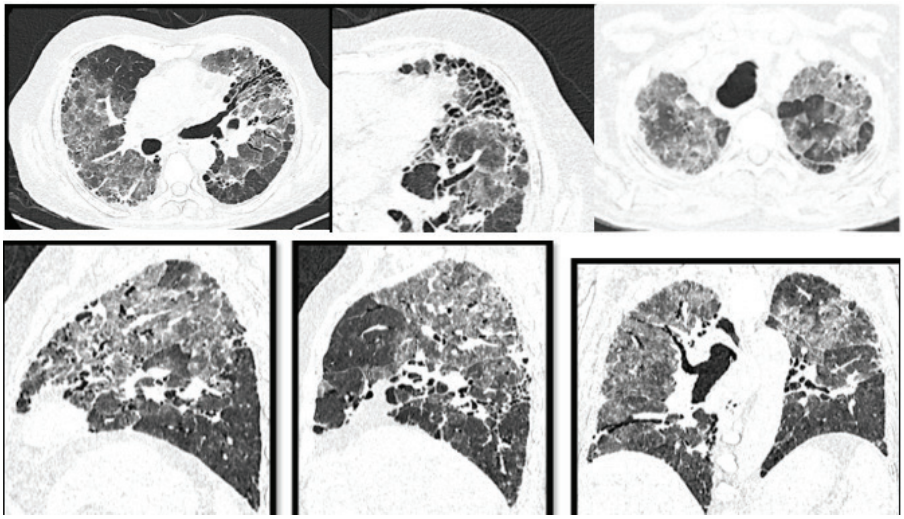

Fig. 2 Non-Specific Interstitial Pneumonia (NSIP)
Axial HRCT lung window images reveal subpleural curvilinear opacities and reticulations. Mild tubular bronchiectasis (white arrow) is also seen

symmetrical ground-glass opacities, fine reticulations with basal predominance, and relative sparing of the immediate subpleural region. The absence of honeycombing, architectural distortion, and significant traction bronchiectasis further supports the NSIP pattern.

Diffuse areas of ground glass opacification with associated traction bronchiectasis were seen in both lungs of 6 (20 %) patients. These were more predominant in upper lobes. There was ancillary irregular interstitial septal thickening and architectural distortion due to fibrosis. More than 80 percent of the lung parenchyma was affected. Subpleural areas of honeycombing were seen in both lungs, showing predominance in their upper portions. The diffuse ground glass abnormality also revealed interspersed areas of normal and hypoattenuating lung parenchyma on expiratory scan. Hypoattenuating areas were possibly due to air trapping (Table 2).

The analysis of lung parenchymal involvement severity on HRCT among the studied cases showed that moderate (25-50 %) and severe (>50 %) involvement were the most common, each observed in 40 % of the patients. Mild involvement (<25 %) was seen in 20 % of the cases (Table 3).

Discussion

In this study involving 30 patients, 63.33% were male and 36.67% were female, with a

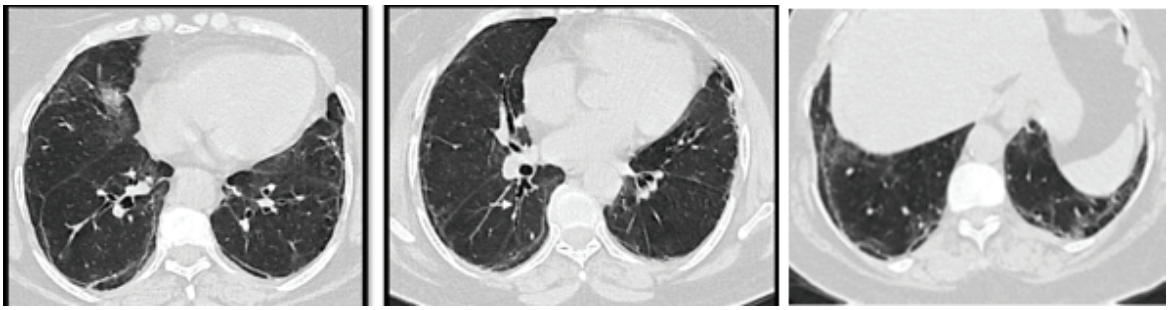

Fig. 3 Chronic Hypersensitivity Pneumonitis (CHP)
Axial CT images reveal extensive ground glass opacities, interstitial septal thickening, traction bronchiectasis, honeycombing and mosaic attenuation. Sagittal and coronal images display predominant upper lobe involvement

male-to-female ratio of 1:0.57. The mean age of male patients was 59.1±9.8 years, while for females, it was 56.8±11.2 years, with an overall mean age of 57.95±10.5 years. Balas Z C *et al* conducted a prospective observational study to compare spirometry findings in ILD patients with their radiological and clinical features.[12] For this purpose, the authors undertook a study comprising of 50 ILD patients who were diagnosed based on clinical and radiological criteria. A detailed history was obtained, and all patients underwent clinical examination and basic investigations. The study found that idiopathic pulmonary fibrosis was the most common ILD, accounting for 32 (64 %) patients. The average duration of symptoms was 5.46±5.49 months, and the mean age of patients was 61.58±12.92 years, ranging from 27 to 88 years. There were 27 (54 %) males and 23 (46 %) females. Chest X-ray findings showed reticular opacities in 24 (48 %) patients, while HRCT revealed ground-glass opacity in 33 (66 %) patients. Male gender predominance as well as mean age of cases with ILD seen in this study was similar to this study. Similar male preponderance in cases of ILD was also reported by the authors such as Ozaki *et al*[13] and Kawano-Dourado *et al*.[14]

A definite UIP pattern was identified in 60 % of patients, characterized by basal-predominant honeycombing with accompanying fine reticulations and traction bronchiectasis. Among these, one-third of cases demonstrated extensive involvement (>50 % of lung parenchyma), while two-thirds exhibited an intermediate degree (25 % –50 %) of fibrosis. Notably, air trapping was absent in all cases, suggesting that small airway involvement was not a predominant feature in this cohort. Interestingly, 16.7% of UIP cases also displayed upper-lobe predominant paraseptal emphysema, fulfilling the criteria for combined pulmonary fibrosis and emphysema (CPFE). These findings align with prior studies, such as those by Douglas D *et al*. who reported that CPFE is a distinct radiological entity within the fibrotic ILD spectrum, associated with a high prevalence of smoking history and a worse prognosis due to coexisting airway destruction and vascular abnormalities.[15] Similarly, Amariei *et al*. demonstrated that CPFE patients often exhibit preserved lung volumes with severely impaired diffusion capacity, reinforcing the complex interplay between emphysematous and fibrotic changes.[16]

A nonspecific interstitial pneumonia (NSIP) pattern was identified in 20 % of cases, demonstrating subpleural curvilinear opacities with fine reticulations and relative subpleural sparing, a hallmark feature differentiating NSIP from UIP. Additionally, scattered GGO was present, with less than 25 % lung involvement in all cases. These findings are in concordance with the study by Teoh AKY *et al* which described NSIP as a histologically distinct entity often associated with autoimmune diseases, particularly systemic sclerosis.[17] Furthermore, Hobbs S reported that the presence of scattered GGO and subpleural sparing on HRCT is a key differentiator of NSIP from UIP, aiding in noninvasive diagnosis.[18]

Chronic hypersensitivity pneumonitis (HP) was identified in 20% of cases, exhibiting a pattern of diffuse GGO with associated traction bronchiectasis, predominantly affecting the upper lobes. Additional findings included interstitial septal thickening, architectural distortion, and subpleural honeycombing, with over 80 % of lung parenchyma involved. These findings are consistent with those reported by Salisbury *et al*., who highlighted that chronic HP is often characterized by upper-lobe predominant fibrosis with mosaic attenuation on expiratory imaging, a key distinguishing feature from UIP and NSIP.[19] More recently, Calaras D *et al*. demonstrated that air trapping in chronic HP is a critical predictor of disease chronicity and progression, supporting the importance of expiratory-phase imaging in the diagnostic evaluation.[20]

The predominance of UIP in this study aligns with existing literature, reinforcing its role as the most common fibrotic ILD pattern. The coexistence of CPFE in a subset of patients further highlights the heterogeneous nature of ILD and its overlap with smoking-related lung diseases. The identification of NSIP and chronic HP in a significant proportion of cases emphasizes the necessity of meticulous HRCT interpretation to ensure accurate classification, as misdiagnosis can have significant therapeutic implications. Furthermore, the absence of air trapping in non-HP cases underscores the importance of expiratory-phase imaging in differentiating various ILD subtypes.

A key limitation of this study is the absence of detailed smoking history, which is particularly important in cases demonstrating combined pulmonary fibrosis and emphysema (CPFE). Since the study was primarily conducted in the radiology department clinical history including occupational and environmental exposures could not be comprehensively

documented. Another key limitation of this study is the absence of formal interobserver agreement analysis using statistical methods such as Cohen's kappa. Although HRCT images were independently reviewed by two radiologists and consensus was reached in cases of discrepancy, the lack of quantified agreement may introduce subjectivity in imaging interpretation.

In conclusion, HRCT plays a crucial role in evaluation of ILD. The predominant pattern in this study was UIP. The presence of CPFE in a subset of patients underlines the importance of clinical correlation particularly in smokers. Differentiating NSIP and chronic HP on imaging carries important prognostic and therapeutic implications. Histopathological correlation is warranted to further refine the radiological classification of ILD and its subtypes.

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