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Patterns and Distribution of Imaging Findings on HRCT Chest in Various ILD's: A Cross-Sectional Study

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Authors' contributions

This work was carried out in collaboration among all authors. Author RAW designed the study, performed the statistical analysis. Author RAM wrote the protocol, and wrote the first draft of the manuscript and author MAN managed the literature searches. Author AAH managed the analyses of the study. All authors read and approved the final manuscript.

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ABSTRACT

Background: Interstitial lung diseases present with diverse clinical, radiological and histological characteristics, yet have significant overlapping features. Different ILDs have different outcomes and need correct diagnosis for appropriate management. UIP, NSIP and sarcoidosis are the most common types. Other important types being COP, RB-ILD, HSP and ILD associated with connective disorders.
Objective: To identify patterns and distributions of imaging findings on HRCT for accurate diagnosis of type of ILDs. HRCT of known cases of ILD was done and predominant imaging features of ILDs documented. We had 75 patients in our study group with male predominance (58.6%). UIP was the most common type of ILD with honeycombing, septal thickening and bronchiectasis as the predominant imaging features with sparse ground glassing. Sarcoidosis was the second most common type of ILD with mediastinal and hilar LAP, perilymphatic nodules, fibrotic bands, septal thickening and bronchiectasis as predominant imaging findings. NSIP presented with

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ground glassing, septal thickening, bronchiectasis, and fibrotic bands as predominant features with no or minimal honeycombing. RB-ILD presented with predominant imaging features of peribronchial thickening, centrilobular nodules, air trapping and fibrotic bands in known smokers. COP presented with predominant imaging features of peripheral consolidations and ground glassings, septal thickenings and bronchiectasis. Lung biopsy is god standard but cannot be performed in every patients owing to higher rates of complication. HRCT has assumed importance in diagnosis and management of ILDs and are relatively specific in its diagnosis.

Keywords: High Resolution Computed Tomography (HRCT); Interstitial Lung Disease (ILD); Usual Interstitial Pneumonia (UIP); Non Specific Interstitial pneumonia (NSIP); Sarcoidosis.

1. INTRODUCTION

Diagnostic approach to ILDs has been confusing as they were categorized according to different clinical, radiological and histological classifications [1,2]. It is essential to differentiate between various disease entities as there are significant differences amongst them in risk factors, pathogenesis, treatment and outcome [3]. The American Thoracic Society (ATS) and European Respiratory Society (ERS) standardized the terminology for ILDs in 2001 [4].This classification includes seven disease entities that include idiopathic pulmonary fibrosis (IPF), nonspecific interstitial pneumonia (NSIP), cryptogenic organizing pneumonia (COP), respiratory bronchiolitis–associated interstitial lung disease (RB-ILD), desquamative interstitial pneumonia (DIP), lymphoid interstitial pneumonia (LIP), and acute interstitial pneumonia (AIP).

High resolution CT scan serves as an important diagnostic modality in evaluating patients with suspected ILD [5]. ILDs are classified based on the histological patterns and each histological pattern is associated with characteristic CT pattern provided that CT acquisition is adequately done [4].

Various patterns of imaging findings in ILD include intra and interlobular septal thickening, ground glassing, bronchiectasis, centrilobular and perilymphatic nodules, honeycombing, focal consolidations, fibrotic bands, air trapping and mediastinal and hilar lymphadenopathy. Interlobular septal thickening can be smooth, irregular and nodular type. Smooth pattern is the most common and least specific types predominantly seen in pulmonary edema. Irregular type is commonly associated with ILDs. whereas, nodular type is associated with specific types of diseases like sarcoidosis, silicosis and lymphoproliferative disorders [6].

Ground glassing pattern refers to increased attenuation of lung without obscuration of bronchovascular structures. Ground glassing is itself nonspecific, however associated presence of fibrosis and bronchiectatic changes points towards the diagnosis of fibrotic lung diseases. Upper lobe predominance is seen in respiratory bronchiolitis and pneumocystis pneumonia; lower zone predominance is noted in UIP, NSIP and DIP while as centrilobular distribution is seen in HSP and respiratory bronchioloitis [7].

Bronchiectasis refers to irreversible dilatation of bronchi and is noted in postinfectious conditions and fibrosing lung diseases. Predominant pattern seen in ILD is tractional bronchiectasis. It is upper lobe predominant in sarcoidosis; lower lung zone and peripheral predominant in pulmonary fibrosis and middle lobe and lingular predominant in ARDS [8].

Nodules can be soft tissue or ground glass attenuation foci generally less than 1cm in size and can be centrilobular, perilymphatic and random in distribution. Centrilobular nodules are predominantly seen in respiratory bronchiolitis (RB-ILD, HSP and Bronchiolitis obliterans) whereas perilymphatic distribution is noted in sarcoidosis, silicosis and lymphoproliferative disorders [9].

Honeycombing is defined as multiple clustered cystic areas usually in subpleural and basal distribution in a layered pattern with thick shared walls between cysts. They represent end stage fibrotic lung disease. Among idiopathic interstitial pneumonias, IPF is a progressive disease often with acute exacerbation and show far worse prognosis than other chronic pneumonia. It is most commonly associated with UIP pattern of ILD [10,11,12]. Microcystic honeycombing can be associated with NSIP pattern as well.

Consolidations appear as areas of increased attenation with obscuration of underlying bronchovascular structures and air bronchogram sign. In various patterns of ILD, they are usually peribronchovascular and peripheral in location. It is noted in various types of ILDs: COP, AIP, acute HP, acute exacerbation of ILD and sarcoidosis [13,14].

Parenchymal fibrotic bands are linear or reticular hyperattenuating areas in lung parenchyma usually extending to visceral pleura and are commonly found in sarcoidosis, asbestosis, silicosis, SLE and sequele of ARDS [15].

Peribronchiolar thickening represents an abnormal bronchial wall thickening and may represent cellular and fluid infiltration or peribronchial fibrosis. It is predominantly seen RB-ILD, DIP and COP types of ILD. Peribronchial thickening can also be seen in pulmonary edema, asthma, cystic fibrosis and in infective etiologies [16].

Mediastinal lymphadenopathy is a common feature in IIPs, being less common in COP than other idiopathic interstitial pneumonias. Mediastinal lymphadenopathy is common in sarcoidosis with typical hilar and right para-tracheal distribution. However, it is of limited value in diagnosis of other ILDs and does not correlate to any other specific HRCT pattern or the extent of disease [17].

1.1 Aims and Objectives

Our study is aimed at identifying patterns, distribution and co-occurrence of imaging findings in various ILDs and their role in narrowing of differential diagnosis in ILDs.

2. MATERIALS AND METHODS

Study conducted our study in Government Medical College Hospital, Srinagar and its associated Chest disease hospital over a period of 18 months from July 2018 to December 2019. It is a cross-sectional type of descriptive study where patients with known ILDs were taken for HRCT lung and findings were documented.

A detailed history was taken and then patients were subjected to HRCT chest after proper consent. All studies were performed using a standard HRCT protocol. Axial sections were acquired at 0.625-mm collimation in deep suspended inspiration and reconstructed at 1.5 mm. Images were displayed at a window width of 1000 to 1600 and a mean of _600 to_700. We performed HRCT chest on Siemens CT scan machine installed at superspeciality hospital GMC Srinagar with 256 slice scanner and with 16 slice scanner at Chest disease hospital Srinagar.

Patients with already diagnosed ILDs and those with clinical findings and associated radiological findings pointing towards specific causes of ILD were taken for study. Patients with biopsy proven ILD were taken for the study with the type of ILD documented. Also, patients with no biopsy but with underlying aetiologies or systemic diseases with secondary lung involvement were taken. These include patients with connective tissue disorders like SLE, RA and scleroderma and those patients with inciting factors like drugs, smoking and allergens with supporting radiological findings.

2.1 Inclusion Criteria

1. Patients with biopsy proven ILD.
2. Patients with inciting factors like drugs, allergens and smoking coincident with radiological features.
3. Patients with underlying connective tissue disorders with secondary lung involvement.
4. Patients with HRCT findings typical for diagnosis of a particular type of ILD like typical UIP pattern.

2.2 Exclusion Criteria

1. Patients with clinical, radiological and microbiological findings consistent with infective lung disease.
2. Patients with predominant emphysematous lung disease.
3. Patients with known lung malignancy.
4. Patients with occupational lung diseases like asbestosis , silicosis

2.3 Statistical Methods

Data were analyzed using the statistical package NCSS 2020. Data are expressed as mean ± standard deviation (SD), median (interquartile range), or as number (percentage). Categorical data were compared using the chi square test.

3. RESULTS

75 patients were enrolled in our study with ages range of 37-70 years (mean age 53.5). There were 31(41.3%) females in our study group and

44 (58.7%) were males. Smoking history was noted in 27 (36%) patients. Dry cough was most common symptom noted in 60 patients (80%) followed by breathlessness in 47 patients (62.7%), fatigue in 15 patients (20%), chest pain in 9 (12%), fever in 7 (9.3%) and joint pains in 6 patients (8%).

Findings on HRCT are in tabulated form as below:

4. DISCUSSION

We conducted our study on 75 patients over a period of 18 months. Males were the predominant sex group with male to female ratio of 1.42 which was comparable to a study conducted by Coultas DB et al. [18] who found male to female ratio of 1.53. Xaubet A et al. [19] in their study found male to female radio of 1.2.

Interlobular septal thickening was the most common imaging finding in our study group (62.7%) followed by ground glassing (58.7%), fibrotic bands (49.3%), bronchiectasis (49.3%) and honeycombing (40%). A study performed by Sahajal Dhooria et al. [20] found interlobular septal thickening as predominant finding followed by intralobular septal thickening, ground glassing and honeycombing.

Among various types of ILDs, UIP was the most common form of ILD in or study group (24%) followed by NSIP (16%), sarcoidosis (16%), RB-ILD (10.7%) and COP (10.6%). S J Bourke [21] in his study found UIP as the most common pattern of ILD followed by NSIP which is consistent with our finding. Similarly studies conducted by Coultas D B et al. [18] and Xaubet A et al. [19] found IPF to be most common ILD type. However, studies conducted by Thomeer M et al. [22] and Tinelli C et al. [23] found sarcoidosis to be most common type of ILD followed by UIP.

Table 1. Percentage wise distribution of imaging findings in ILD

HRCT findings	NO OF PATIENTS (n=75)	Percentage
Inter-lobular septal thickening	47	62.7%
Intralobular septal thickening	21	28%
Centrilobular nodules	18	24%
Perilymphatic nodules	17	22.7%
Bronchiectasis	37	49.3%
Consolidation	11	14.6%
Ground glassing	44	58.7%
Peribronchial thickening	26	34.7%
Air trapping	18	24%
Honeycombing	30	40%
Prenchymal fibrotic bands	37	49.3%
Mediastinal and hilar lymphadenopathy	26	34.7%

After HRCT radiological impression was made and UIP was most common ILD and LIP was least common diagnosis

Table 2. Relative percentage of various types of ILD

Radiological impression	No of patients	Percentage
UIP (Usual Interstitial pneumonia)	18	24%
NSIP (Nonspecific interstitial pneumonia)	12	16%
Sarcoidosis	12	16%
RB-ILD (Respiratory bronchiolitis interstitial lung disease.)	8	10.7%
COP (cryptogenic Organising pneumonia)	8	10.6%
HSP (Hppersensitivity pneumonitis)	7	9.3%
AIP(Acute Interstitial pneumonia)	3	4%
Rheumatoid arthritis	3	4%
Systemic lupus erythematosis	2	2.7%
Acute exacerbation of ILD	2	2.7%

Table 3. Relative percentage of imaging findings in Usual interstitial Pneumonia (UIP) (n=25)

Predominant imaging finding	Honeycombing	Bronchiectasis	Septal thickening	Ground glassing	Fibrotic bands	Mediastinal LAP
Number of patients	25	21	22	8	18	13
Percentage	100%	84%	88%	32%	72%	52%

Table 4. Relative percentage of imaging findings in Nonspecific Interstitial Pneumonia (NSIP) (N=12)

Predominant imaging finding	Ground glassing	Septal thickening	Bronchiectasis	Fibrotic bands	Honeycombing	Peribronchial thickening	Mediastinal LAP
Number of patients	12	9	10	8	1	7	8
Percentage	100%	75%	83.3%%	66.7%	8.3%	58.3%	66.7%

Table 5. Relative percentage of imaging findings in sarcoidosis (n=12)

Predominant imaging finding	Perilymphatic nodules	Fibrotic bands	Bronchiectasis	Mediatinal LAP	Peribronchial thickeneing	Ground glassing	Septal thickening
Number of patients	10	9	5	11	4	3	5
Percentage	83.3%	75%	41.7%	91.7%	33.3%	25%	41.7%

Table 6. Respiratory Bronchiolitis- Interstitial Lung Disease (RB-ILD) (n=8)

Predominant imaging finding	Peribronchial thickening	Air trapping	Centrilobular nodules	Fibrotic bands	Ground glassings	Septal thickening	Bronchiectasis
Number of patients	7	4	7	5	3	4	1
Percentage	87.5%	50%	87.5%	62.5%	37.5%	50%	12.5%

Table 7. Relatiev percentage of imaging findings in Cryptogenic Organizing Pneumonia (COP) (n=8)

Predominant imaging finding	Peripheral consolidation	Ground glassing	Bronchiectasis	Peribronchial thickening	Peribronchial nodules	Interlobular septal thickening
Number of patients	8	7	3	4	3	5
Percentage	100%	87.5%	37.5%	50%	37.5%	62.5%

Table 8. Relative percentage of imaging findings in Hypersensitivity Pneumonitis (HSP) (n=7)

Predominant imaging finding	Ground glassing	Air trapping	Peribronchial thickening	Septal thickening	Centrilobular nodules	Mediastinal LAP
Number of patients	7	6	5	5	5	2
Percentage	100%	85.7%	71.4%	71.4%	71.4%	28.6%

Table 9. Relative percentage of imaging findings in Acute Interstitial Pneumonitis (AIP) (n=3)

Predominant imaging finding	Ground glassing	Consolidation	Bronchiectasis	Peribronchial thickening	Centrilobular nodules	Fibrotic bands
Number of patients	3	2	1	2	1	1
Percentage	100%	66.7%	33.3%	66.7%	33.3%	33.3%

Table 10. Relative percent of imaging findings in Rheumatoid Arthritis (RA) (n=3)

Predominant imaging finding	Ground glassing	Rheumatoid nodules	bronchiectasis	Centrilobular nodules	Honeycombing	Fibrotic bands	Mediastinal LAP
Number of patients	2	1	2	1	2	2	1
Percentage	66.7%	33.3%	66.7%	33.3%	66.7%	66.7%	33.3%

Table 11. Relative percentage of imaging findings in Systemic Sclerosis(SS) (n=2)

Predominant imaging finding	Septal thickening	Ground glassing	Bronchiectasis	Peribronchial thickening	Fibrotic bands
Number of patients	2	2	1	1	2
Percentage	100%	100%	50%	50%	100%

Table 12. Relative percentage of imaging findings in Acute Exacerbation of ILD (n=2)

Predominant imaging finding	Ground glassing	Honeycombing	Septal thickening	Consolidation	Bronchiectasis	Fibrotic bands	Mediatinal LAP
Number of patients	2	1	2	1	1	2	1
Percentage	100%	50%	100%	50%	50%	100%	50%

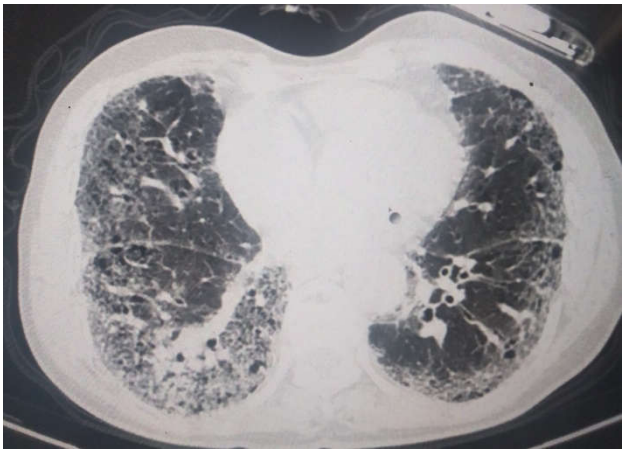

Fig. 1. HRCT lung window in a patient of Usual Interstitial Pneumonia (UIP) showing sub-pleural honeycombing in bilateral lungs

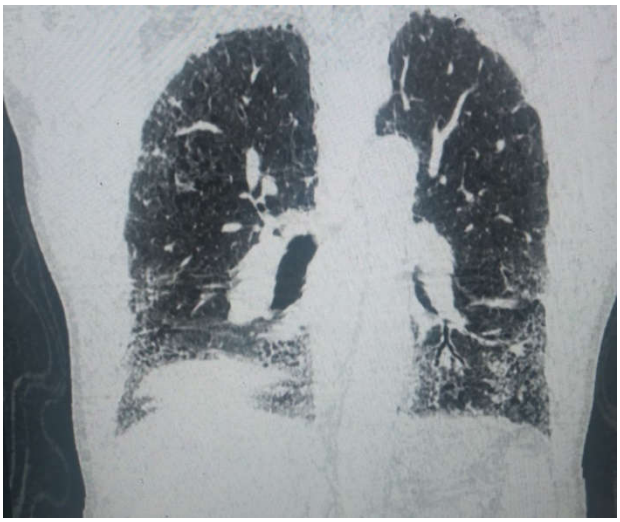

Fig. 2. Coronal HRCT lung window showing apico-basal gradient of honeycombing in UIP

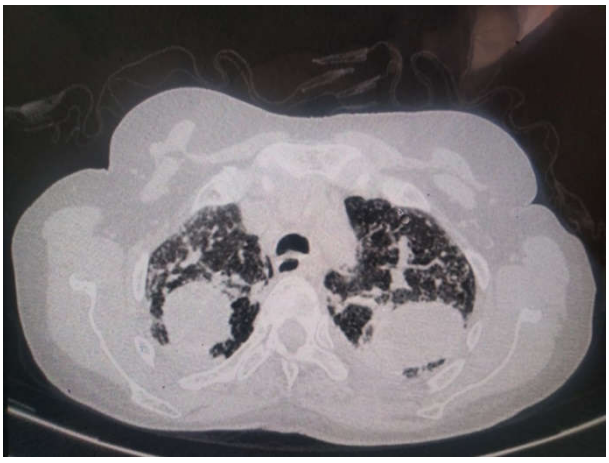

Fig. 3. Axial HRCT Lung window showing mass like opacities in bilateral upper lobes in a known case of sarcoidosis

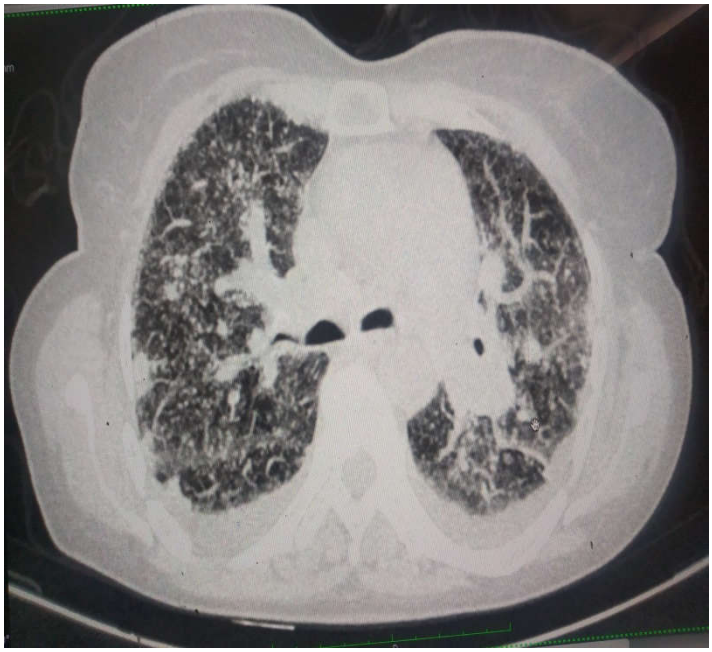

Fig. 4. HRCT lung window in 35 year old female shows perilymphatic distribution of nodules diagnosed with sarcoidosis

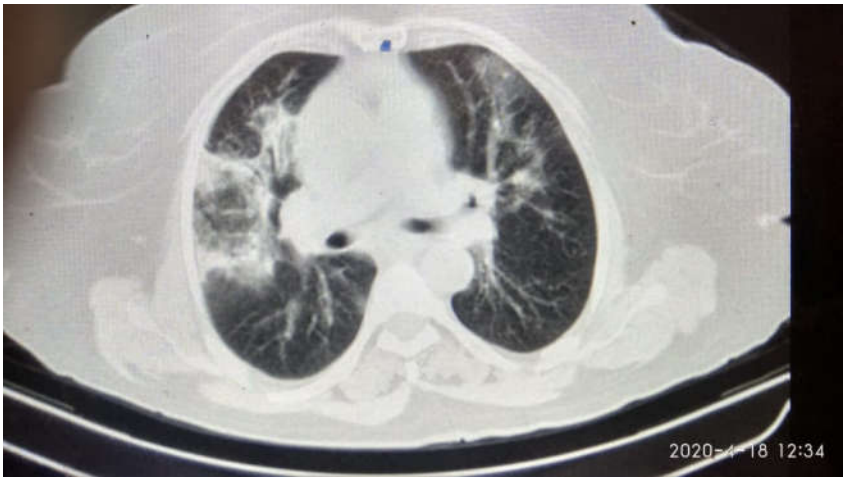

Fig. 5. Axial HRCT chest showing organised consolidation with Atoll sign in right lung in a case of Cryptogenic organising Pneumonia

UIP was the most common ILD type in our study group. Honeycombing was the most common imaging finding in UIP (100%). It was predominantly subplueral in location with apicobasal gradiant. It was the most specific finding of UIP pattern of ILD making about 18 patients of all 30 cases of honeycombing. Other associated findings suggesting UIP pattern from our study are bronchiectasis (83.3%), septal thickening predominantly intralobular (88.9%) and fibrotic bands (72.2%). Ground glassing was only noted in a small number of patients (33%) and was not the predominant imaging finding. Masanori Akira et al. [24] in their study found that honeycombing, reticulations and tractional bronchiectasis were the most common imaging features of UIP differentiating it from NSIP which had ground glassing and consolidations as predominant imaging features. Hence, the presence of honeycombing with reticulations, tractional bronchiectasis and fibrotic bands with sparse ground glassing favours the diagnosis the UIP pattern of ILD. Temporal inhomogeneity is characteristic.

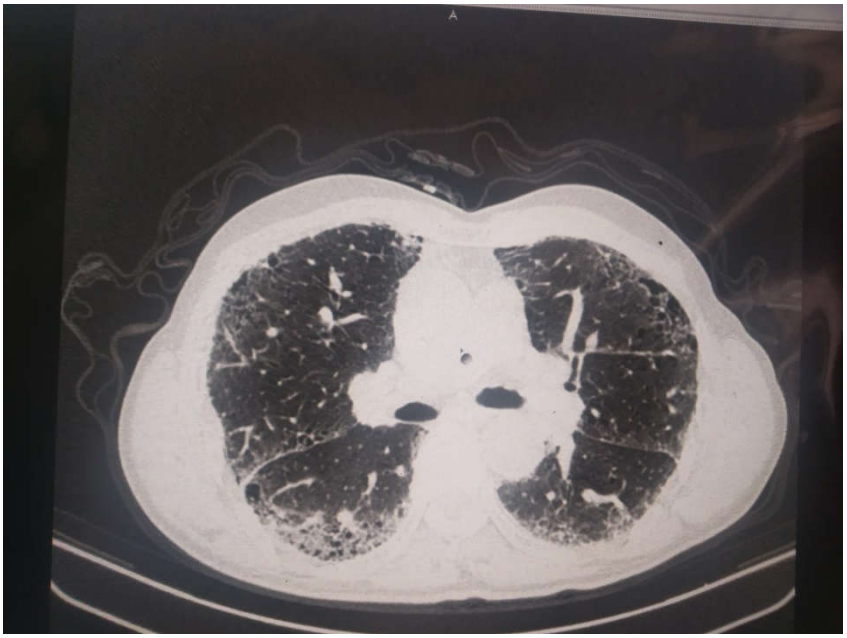

Fig. 6. Axial HRCT chest in a known case of Rheumatoid arthritis showing sub-pleural honeycombing and architectural distortion in both lungs

NSIP and sarcoidosis were the second most common pattern of ILD in our study group. Most common imaging finding in NSIP was ground glassing (100%) followed by fibrotic bands (66%), septal thickening (75%), peribronchial thickening (58.3%) and bronchiectasis (83.3%). Honeycombing was seen in only one patient of NSIP in our study group (8.3%). Ground glassing was found in all patients of NSIP predominantly involving lower lobes. Seth J Kligerman et al. [25] in their study concluded that ground glassing is a salient feature of NSIP and NSIP is ruled out in its absence. Tractional bronchiectasis was the second most common imaging finding in NSIP followed by septal thickening. Microcystic honeycombing was noted in only one patient. Likewise, Nishiyama et al. [26] in their study found bronchiectasis in 93% of cases of NSIP followed by intralobular septal thickening. Hence the presence of lower lobe predominant ground glassing along with bronchiectasis and septal thickening with no or minimal honey combing strongly favours the diagnosis of NSIP.

Mediastinal lymphadenopathy was seen in 55.6% of UIP and 66.7% of NSIP and hence has limited role in the diagnosis of UIP and NSIP. These findings are in correlation with a study conducted by Carolina Althoff Souza et al. [27] who found mediastinal lymphadenopathy in 66% and 81% of UIP and NSIP patients respectively.

Sarcoidosis is characterised by medistinal lymphadenopathy (91.7%), perilymphatic nodules (83.3%), fibrotic bands (75%), septal thickening (41.7%), bronchiectasis (41.7%) and peribronchial thickening (33.3%). Ground glassing was noted in 25% of cases. Mediastinal lymphadenopathy was the most common imaging finding supported by a study conducted by Michael Avital et al. [28] where they noted mediastinal lymphadenopathy in 89% of patients followed by micronudules, ground glassing and septal thickening albeit in lesser number of cases. In a study conducted by Peeyush Kumar Dhagat et al. [29] mediastinal lymphadenopathy was the predominant imaging finding followed perilymphatic nodules. Mediastinal nodes are predominantly seen in right paratracheal and bilateral hilar in location. We had one case of atypical sarcoidosis with imaging finding of large pulmonary masses in bilateral upper lobes. They are formed as a result of coalescing of nodules with some showing air bronchogram sign and are sometimes referred to as alveolar sarcoidosis [30].

Respiratory bronchiolitis-ILD is the most common ILD associated with smoking. Peribronchial thickening (87.5%) was the most common imaging finding in our study followed by centrilobualr nodules (87.5%), fibrotic bands (62.5%), septal thickening (50%), air trapping (50%) and ground glassing (37.5%). Park JS et al. [31] reported that peribronchial thickening was the most common imaging finding followed by centrilobular nodules, air trapping and ground

glassing. Hence the presence of peribronchial thickening, centrilobualr nodules, septal thickening and air trapping in a smoker strongly favours the diagnosis of RB-ILD.

Cryptogenic organizing pneumonia (COP) is characterised by peripheral consolidations, ground glassing, peribronchial thickening and septal thickeining. Atoll sign is characteristic of COP and was noted in 37.5% of patients in our study group. Peripheral consolidation (100%) was the most common imaging finding followed by ground glassing (87.5%), septal thickening (62.5%), peribronchial thickening and bronchiectasis (37.5%). Peripheral and peribronchial consolidations along with ground glassing, peribronchial thickening and septal thickenings makes the diagnosis of COP high likely [32].

Subacute or chronic Hypersensitivity Pneumonitis patients are commonly referred for the radiological examinations as the acute HSP has rapid resolution of symptoms. HSP is radiologically characterized by patchy or diffuse ground glass opacities, poorly defined centrilobular nodules and areas of decreased attenuation suggestive of air trapping. In our study, ground glassing was seen in 100% of cases followed by air trapping (85.7%), centrilobular nodules (71.4%), peribronchial and septal thickening. Our findings are consistent with the study conducted by C Isabela S silva et al. [33] who found Ground glass opacities, centrilobular nodules and areas of reduced attenuation as predominant HRCT findings. 75% of patients in our study group gave history of occupational exposure to allergens as the triggering factor for HSIP.

Acute interstitial pneumonitis (AIP) is the only type of ILD with acute presentation. It is characterised by bilateral symmetric areas are ground glassing with patchy and diffuse distribution and associated air space consolidation [34]. Ground glassing was the most common imaging finding in our study group (100%) followed by air space consolidation (66.7%), peribronchial thickening (66.7%), and bronchiectasis (33.3%). S L Primack et al. [34] found air space consolidation and bilateral ground glassing in all patients with predominant lower zone predominance and concluded that imaging features are similar to ARDS and represent acute alveolar damage.

We had three RA patients with lung involvement; two with UIP pattern (66.7%) and one with NSIP pattern (33.3%). Ground glassing, honeycombing and bronchiectasis were the most common imaging findings. Rheumatoid nodules were found in 33.3% of patients. UIP pattern was the most common type in a study conducted by Eunice J Kim et al. [35] followed by NSIP pattern.

We had two cases of systemic sclerosis-ILD and both showed NSIP pattern of ILD with ground glassing and septal thickening as predominent imaging findings. No honeycombing was noted in any of the cases. Most common imaging finding in a study performed by Diane Strollo et al. [36] were ground glassing and interstitial thickening; noted greatest in lung bases. In advanced cases, tractional bronchiectasis and honeycombing can be seen.

HRCT chest has several limitations and accurate diagnosis is at times challenging. UIP and NSIP present with similar clinical symptoms but UIP has a worse prognosis and hence needs accurate diagnosis. Several studies have proven high accuracy of HRCT in diagnosis of UIP in patients with typical HRCT findings. However, diagnosis of NSIP usually requires biopsy for the diagnosis [37,38]. HRCT can miss about 30-40% of cases of UIP which later proved to be UIP on subsequent biopsies. NSIP is mimicked by various ILDs including HSP, LIP, RB-ILD, and DIP. However, lung biopsy is invasive procedure and is associated with significant complications and mortality. Pneumothorax is the most common complication associated with the procedure (17-26%) [39].

Hence, biopsy is not feasible on every patient with suspected ILD and HRCT has assumed significant importance in diagnosis and management of ILDs.

Our study had some limitations. We had relative small sample size of cases. Patients with known tubercular lung disease and Pneumoconiatic lung diseases were excluded from the study to avoid misinterpretation of imaging findings. Also patients with lung cancers were excluded from the study to avoid misinterpretation of fibrotic changes in lung associated with chemo-radiotherapy with ILDs.

5. CONCLUSION

From our study, we came to the conclusion that ILDs although having many overlapping features, have certain typical features on HRCT which aid in their diagnosis. Lung biopsy is gold standard but cannot be employed in every patient because

of complications associated with it and HRCT chest guides in diagnosis and management of various types of ILDs.

CONSENT

As per international standard or university standard written patient consent has been collected and preserved by the author(s).

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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