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Revisiting the imaging plethora of interstitial lung diseases by high resolution computed tomography: an observational study at a tertiary hospital in north western Rajasthan

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Abstract

Introduction: The interstitial lung diseases are a heterogenous group of many acute and chronic pulmonary disorders. Though individually rare, as a group, they are a common clinical problem. Though they are grouped together, there are great variations in the risk factors for their development, their pathological processes, the relevant therapies and the associated prognosis, making an accurate diagnosis very essential to minimize early complications and its sequelae.

Objectives of the study: Characterizing the various HRCT patterns of Interstitial Lung Disease (Idiopathic Interstitial Pneumonias) like: • Honeycombing • Bronchiectasis • Bronchiolectasis • Reticulation • Ground glass opacities • Air trapping • Consolidation. • Fibrosis.

Methodology:

Study Area: Study was carried out in the Department of Radiodiagnosis & Modern Imaging, S.P. Medical College & A.G. of P.B.M. Hospitals, Bikaner. This hospital is a tertiary care centre equipped with GE 128 Slice Revolution evo CT scanner.

Study Population: All the patients (out patient as well as in patient) referred for HRCT of chest were included in the study.

Study Design: This is a cohort descriptive and observational study.

Sample Size: 80 patients with positive findings of interstitial lung disease (In patients and Out patients)

Study Duration: 1 year or till 80 patients completed.

Inclusion Criteria:

- All the patients with clinically suspected interstitial lung disease referred for HRCT were included in the study after taking their informed consent.
- All age groups and both the sexes, including children, adult and old age patients were included in study.

Exclusion Criteria:

The following patients were excluded from the study -

- Patients with associated lung pathology like mass or any other significant lung pathology.
- Hemodynamically unstable and unconscious patients.
- All patients who did not gave consent to be a part of the study.

Results & Conclusion: High resolution computed tomography (HRCT) is very effective in visualizing the distorted architecture of lung parenchyma in Idiopathic Interstitial Pneumonias. As compared to chest radiographs and conventional CT, HRCT is capable of detecting disease processes much earlier in their evolution.

Based on the HRCT features a histospecific diagnosis can be reached in most cases of Idiopathic Interstitial Pneumonias obviating the need for biopsy. The disease activity can also be depicted, thereby guiding the treatment strategy. The findings of this study correlate well with many other studies reported in literature.

Keywords: Lung, HRCT, interstitial, pneumonia, imaging, ground glass, honeycombing

Introduction

Interstitial lung diseases are a diverse group of diseases which affect the lung interstitium and share similar clinical and radiological manifestations. They are heterogeneous group of disorders of the lower respiratory tract that are characterized by both acute and chronic inflammation and a generally irreversible and relentless process of fibrosis in the interstitium and the alveolar walls [1].

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The interstitium refers to tissues of the alveolar wall between the capillary endothelium and the alveolar epithelium and it is the site of primary injury. The term "interstitial" can be misleading as most of these conditions also affect the airway spaces and even the blood vessels, but it is the predominant and primary involvement of the interstitium that characterizes those [2].

The interstitial lung diseases are a heterogeneous group of many acute and chronic pulmonary disorders. Though individually rare, as a group, they are a common clinical problem. Though they are grouped together, there are great variations in the risk factors for their development, their pathological processes, the relevant therapies and the associated prognosis, making an accurate diagnosis very essential [3].

The last century experienced remarkable advances in the classification, diagnosis and understanding of the pathogenesis of the interstitial lung diseases. Technological advances, particularly physiologic testing, lung imaging studies, bronchoalveolar lavage, surgical lung biopsy and histopathologic assessment improved our understanding of these entities. In particular, the advent of high-resolution computed tomography, the narrowed pathologic definition of usual interstitial pneumonia, and recognition of the prognostic importance of separating usual interstitial pneumonia from other idiopathic interstitial pneumonia patterns have profoundly changed the approach to these processes. Most recently, genetic medicine, the use of new technologies (e.g., Microarrays, mass spectroscopic analysis of proteins, and laser capture microdissection) and the development of animal models have had a major impact on understanding the pathogenesis and potential molecular targets for interfering with fibrogenesis [4].

Interstitial lung diseases are characterized by anatomical distortion of peripheral airways and interstitium, determined by a first stage of alveolitis followed by a stage of fibrosis. The natural history of several interstitial lung diseases is characterized by slow and progressive destruction of alveolar-capillary functional units, often with respiratory failure and death. For their smoldering evolution and non-specificity of symptoms (exertional dyspnea and cough), they may remain undiagnosed and not treated for a long time [5, 6]. Herein lies the importance of HRCT and other investigations in aiding for an early diagnosis.

Idiopathic pulmonary fibrosis is the most common interstitial lung disease in adults and generally has a poor prognosis. Idiopathic pulmonary fibrosis (IPF)/usual interstitial pneumonia (UIP) is not a very well-understood entity. Current explanations of the natural history and pathogenesis of IPF/UIP are controversial, and ongoing research continues to investigate multiple hypotheses [7]. Around 15% of patients with interstitial lung disease have an underlying connective tissue disorder [8]. Although interstitial lung diseases are more common in adults, certain forms such as hypersensitivity pneumonitis and idiopathic interstitial pneumonias are seen in children as well [9]. In children, common diseases associated with interstitial lung diseases include viral respiratory tract infections (RSV, parainfluenza, etc.), gastroesophageal reflux, idiopathic pulmonary fibrosis, pulmonary hemosiderosis, eosinophilic pneumonia, pneumonitis associated with AIDS etc. [9-12]

Although there are several interstitial lung diseases, only a few handful of about 10-12 account for more than 90% of them. Among the well over 100 distinct entities of ILDs, a

limited number of disorders, including idiopathic pulmonary fibrosis, sarcoidosis, and connective tissue disease-related ILDs, account for most ILDs encountered clinically [13]. Hence, proper knowledge and understanding of these common entities is pertinent in diagnosing them and also in including them in the differential diagnosis.

For the physician, the distinctive sign of interstitial lung disease is the evidence of diffuse pulmonary opacities on chest X rays or a suggestive pattern on pulmonary function tests. The diagnosis of chronic ILD depends on epidemiologic data, clinical and radiological findings which make it possible to consider a diagnosis of high probability in at least 60% of cases and reduce the gamut of hypothesis in the remaining [14].

In the diagnosis of interstitial lung diseases, clinical, radiological and histological correlation is needed on most occasions. The chest radiogram remains the basic radiological tool in the investigation of these patients [15]. However, chest radiography is relatively insensitive and is normal in 10-20% of patients with histologically proven interstitial lung disease [15]. Many diseases remain occult or are not correctly diagnosed on chest X ray, appearing as a non specific 'reticulonodular pattern' [2]. It is not specific also in that different interstitial lung diseases can have similar radiographic appearances. High-resolution computed tomography of the chest has become an invaluable tool in the diagnostic process of interstitial lung diseases. A confident diagnosis can often be made on the basis of high-resolution computed tomographic findings and the clinical context. Serologic testing can be helpful in selected cases [13]. Improvements in CT scanner technology has now made it possible to image the lung parenchyma with excellent anatomic detail [16]. The morphologic characteristics of diffuse parenchymal lung diseases can be demonstrated with very high resolution. HRCT or high resolution computed tomography is more sensitive than conventional chest radiography in the detection of interstitial lung diseases. However, sensitivity is not 100% [16]. The specificity for the characterization of different lung diseases has been documented and appears to be better than conventional radiography. The ability to characterize different disease processes and to provide a specific diagnosis by HRCT is a big advantage in clinical situations.

To date, numerous reports have documented that HRCT is more sensitive and specific than chest radiography in establishing a diagnosis in diffuse lung diseases. HRCT has proved particularly accurate in establishing the diagnosis of silicosis, idiopathic pulmonary fibrosis, lymphangitic carcinomatosis, and sarcoidosis. In general, the accuracy of plain film diagnosis in the same disorders was much lower [17]. Mathieson *et al.* analyzed the accuracy of HRCT and chest radiography in establishing a specific diagnosis in patients with chronic diffuse infiltrative lung disease. Three different observers independently interpreted plain chest films and HRCT scans, listed the three most likely diagnoses, and assigned a degree of confidence for the first-choice diagnosis. The highest confidence level was reached with 49% of CT scans and 23% of plain chest films, and a correct diagnosis was made with 93% and 77%, respectively. In a large study of patients with chronic diffuse infiltrative lung disease, Grenier *et al.* demonstrated that high resolution CT was of particularly high value when CT images were analyzed together with clinical and radiographic information. Based on clinical information

alone, a confident correct diagnosis could be made in 29% of the cases. Combined interpretation of clinical data and plain film findings increased the confidence in a correct diagnosis to 54%, and to 80% when clinical, radiographic, and HRCT findings were analyzed together. Consequently, most patients with a diagnosis of diffuse lung disease based on plain films will proceed to HRCT to narrow down the differential diagnosis or even to establish a specific diagnosis and to do so with a higher confidence level [17]. Moreover, although there have been numerous studies comparing conventional radiography and HRCT in the diagnosis of specific interstitial diseases, very few studies have incorporated the whole gamut of interstitial lung diseases in a single study. Hence HRCT is currently the most sensitive tool for non-invasive imaging of the lung parenchyma in patients with suspected ILD.

Materials and methods

Study area

Study was carried out in the Department of Radiodiagnosis & Modern Imaging, S.P. Medical College & A.G. of P.B.M. Hospitals, Bikaner. This hospital is a tertiary care centre equipped with GE 128 Slice Revolution evo CT scanner.

Study population

All the patients (out patient as well as in patient) referred for HRCT of chest were included in the study.

Study design

This is a cohort descriptive and observational study.

Sample size

80 patients with positive findings of interstitial lung disease (In patients and out patients)

Study duration: 1 year or till 80 patients completed.

Inclusion criteria

- All the patients with clinically suspected interstitial lung disease referred for HRCT were included in the study after taking their informed consent.
- All age groups and both the sexes, including children, adult and old age patients were included in study.

Exclusion Criteria

The following patients were excluded from the study -

- Patients with associated lung pathology like mass or any other significant lung pathology.
- Hemodynamically unstable and unconscious patients.
- All patients who did not gave consent to be a part of the study.

Data collection procedure

Each patient underwent a thorough clinical evaluation including a detailed history and physical examination. The duration of the complaints were noted in each patient. All the patients were made to undergo HRCT scan as the radiological examination after taking an informed consent for the same.

Equipment

HRCT scan of the thorax was performed using GE 128 Slice Revolution evo CT scanner. It has a minimum scan time of

1.4 seconds. All the images were acquired on 512 x 512 pixel matrix. Operation is system guided and performed via the keyboard.

Guidelines of performing HRCT

Scan Protocol

The scan parameters were

- **Detector collimation:** 64 × 0.6 mm.
- **Slice acquisition:** 128 × 0.6 mm.
- **Gantry rotation time:** 330 milliseconds (temporal resolution, 83 milliseconds);
- **Pitch:** Automatically calculated by the machine, it is usually 0.2–0.47.
- **Tube current:** 390 mAs per rotation;
- **Tube potential:** 120 kV.
- **Scan range:** For routine HRCT sequence, 1 cm above the manubrium till the level of adrenal.

Slice thickness and collimation: Images are acquired with a collimation of 1 mm with position increment of 0.4mm and then latter reconstructed.

Scanning time was approximately 6–9 seconds, depending on the cardiac dimensions and pitch, in a single breath hold in the craniocaudal direction.

Scan direction: The scan direction is cranio-caudal for routine HRCT.

Preparation of patient on the table:

- Hands to be raised above head.
- It is important to practice breath-holding technique on table with patient, as variation in breathing can result in artifacts during acquisition.

HRCT Examination technique

- Scans were obtained with the patient in supine position with full inspiration with a collimation of 5.0 mm and 100 msec acquisition time.
- Images were reconstructed with a high spatial frequency algorithm and photographed at window settings appropriate for viewing the lung parenchyma (Window center -600 HU; Window width 1200HU).

Image Reconstruction

The images were then transferred to a dedicated online workstation Multimodality Work Place (MMWP) for image post-processing techniques. The Maximum Intensity Projection (MIP) and Minimum Intensity projection were reconstructed.

Statistical Analysis

The Statistical Analysis was done using Statistical package for the social sciences (SPSS) Software Ver. 17. The quantitative variables were presented as means and standard deviation and compared using paired t-test. The qualitative variables were presented as frequencies and percentages and compared using chi-square test. The p- value of < 0.05 was considered as significant.

Results

For a period of 12 months, HRCT of chest was performed on 80 patients, which were clinically suspected interstitial lung diseases. Out of 80 patients, 46 patients were male and

34 patients were female. In these maximum number of patients had UIP(34), followed after NSIP(16), HSP(13), IPF(11), COP(5) and RB-ILD was seen in only 1 patient. DIP and LIP are very rare interstitial pneumonias.

The age group of patients ranged from 30 to 90 yrs and most (40%) were found in the age group of 60-69 years followed by 20 % in 70-79 and 21.25 % in 50-59 year age Groups.

The study included a total of 80 patients out of which 46(57.5%) patients were Male and 34(42.5%) patients were female. The study included 29(36.25%) patients who gave a history of smoking while 51(63.75%) patients did not give a history of smoking out of a total of 80 patients. Out of total of 80 patients 34(42.5%) patients showed HRCT pattern reflecting UIP, 16(20%) patients showed NSIP, 13(16.25%) patients had HSP, 11(13.75%) patients showed IPF as well as 5(6.25%) patients had COP while only 1(1.25%) patient showed changes of RB-ILD. Out of total 80 patients maximum number of patients seen in 60-69 age groups, 14(43.8%) in UIP, 7(21.9%) in NSIP, 5(15.6%) in HSP, 3(9.4%) in IPF as well as 2(6.3%) in COP while 1(3.1%) and only patient of RB-ILD. Out of total of 80 patients maximum number of patients, male predominance seen in 18(39.1%) in UIP, 10(21.7%) in HSP, 9(19.6%) in IPF as well as 4(8.7%) in COP while 1(2.2%) and only patient of RB-ILD, except for NSIP where female predominance seen 12(35.3%). Out of total of 80 patients 32(40%) patients came with cough, 22(27.50%) with breathlessness, 21(26.25%) with dry cough and 5(6.25%) with cough and fever.

Out of total of 80 patients maximum no of patients had bronchiectasis 63(78.75%), while only 5(6.25%) patients had consolidation.

Out of total of 80 patients, maximum no of patients 13(61.9%) with dry cough had UIP, 9(28.1%) with cough had NSIP, 6(18.8%) with cough had HSP and 5(100%) patients with consolidation had COP. Out of total of 80 patients, maximum no of smoker 14(48.3%) had UIP, but patients with NSIP had no smoking history. Out of total of 80 patients, 39(44.4%) had ground glass opacities and 41(55.6%) were not associated with ground glass opacities. Maximum no of patients with HSP 13(33.3%) and NSIP 12(30.8%) associated with ground glass opacities.

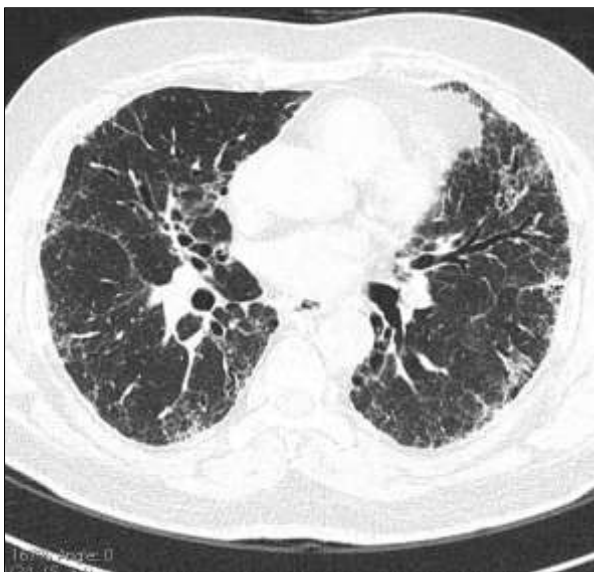


Fig 1: Axial HRCT images of 68-year-old man with progressive shortness of breath due to UIP. Both lung fields show subpleural interstitial thickening with traction bronchiectasis.

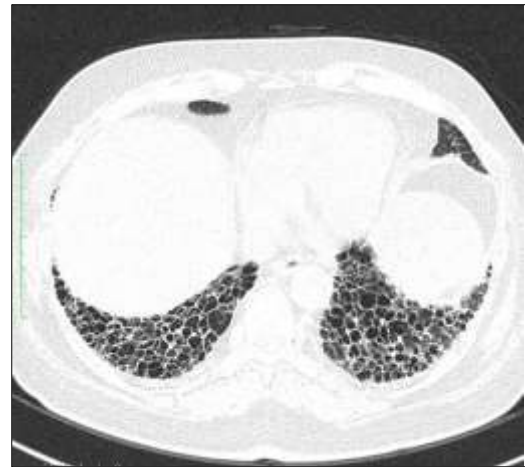


Fig 2: Axial HRCT images in a 66year old man with cough due to UIP. Both the lower lobes show honeycombing consisting of multilayered thick-walled cysts.

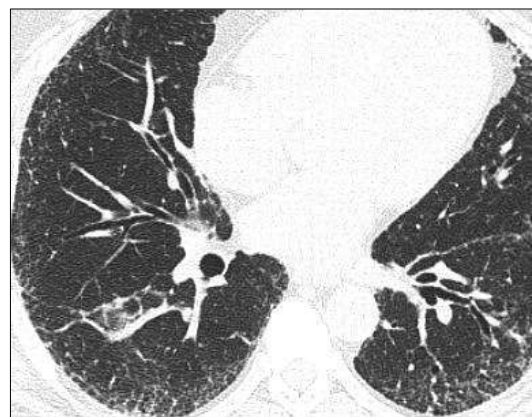


Fig 3: Axial HRCT images of 75-year-old woman with progressive shortness of breath due to UIP. Both lung fields show subpleural interstitial thickening with traction bronchiectasis.

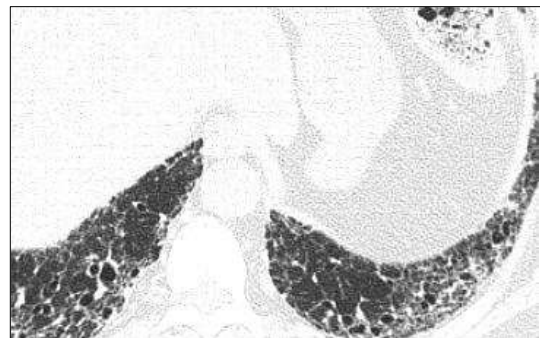


Fig 4: Axial HRCT images in a 66year old man with cough due to UIP. Both the lower lobes show honeycombing consisting of multilayered thick-walled cysts.



Fig 5: Axial HRCT images in 55 year old male patient with biopsy proven COP, shows patchy areas of subpleural consolidations in both lung fields.

Summary and conclusion

The present study included 80 patients with interstitial lung disease (Idiopathic Interstitial Pneumonias) of differing age groups. Most of the patients had vague complaints of breathlessness, cough or dry cough.

All patients had an HRCT done with 5.0 mm collimation scans taken at variable slice intervals which were reconstructed using high spatial frequency algorithm.

The normal anatomy of the secondary pulmonary lobule with its various morphological features was identified. The HRCT of patterns each Idiopathic Interstitial Pneumonias were studied.

UIP and IPF affect the basal and peripheral areas of the lung. They are characterized on HRCT images by the presence of reticular opacities, often associated with traction bronchiectasis. Honeycombing is common.

Ground-glass opacity is also common but is usually less extensive than the reticular pattern. Architectural distortion, which reflects lung fibrosis, is often prominent.

NSIP is characterized by ground glass opacities which is its salient feature and is associated with reticulation, bronchiectasis and lobar volume loss.

HSP is characterized by ground glass opacities with air trapping which are its salient features and associated findings like nodules, fibrosis and bronchiectasis.

COP is seen as patchy areas of consolidation (subpleural or peribronchial distribution) with ground glass opacities. RBILD is seen as patchy areas of ground glass opacities, centrilobular nodules and in later stages fibrosis.

Thus high resolution computed tomography is very effective in visualizing the distorted architecture of lung parenchyma in Idiopathic Interstitial Pneumonias. As compared to chest radiographs and conventional CT, HRCT is capable of detecting disease processes much earlier in their evolution.

Based on the HRCT features a histospecific diagnosis can be reached in most cases of Idiopathic Interstitial Pneumonias obviating the need for biopsy. The disease activity can also be depicted, thereby guiding the treatment strategy.

The findings of this study correlate well with many other studies reported in literature.

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