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Role of Imaging Modalities in diagnosis of Interstitial Lung Disease

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Abstract

Interstitial lung diseases (ILDs) are a diverse group of pulmonary disorders with significant morbidity and mortality. Idiopathic Interstitial Pneumonias (IIPs) represent a major subset, characterized by varying patterns of inflammation and fibrosis within the lung parenchyma. This study aims to assess the diagnostic role of conventional chest radiographs compared to high-resolution computed tomography (HRCT) in identifying ILDs, particularly IIPs. A cross-sectional observational study was conducted on 100 patients with suspected ILD, evaluating imaging findings, demographic patterns, and disease distribution. HRCT demonstrated superior sensitivity (90%) and specificity (70%) in detecting ILD compared to chest radiographs (84% accuracy). Among IIPs, usual interstitial pneumonia (UIP) was the most prevalent (46.55%), followed by non-specific interstitial pneumonia (31.03%). The study also highlighted the association of ILDs with age, smoking, and collagen vascular diseases. HRCT emerged as the preferred imaging modality, effectively differentiating ILD subtypes, identifying early disease manifestations, and guiding clinical management. The findings emphasize the necessity of HRCT for accurate ILD diagnosis, reducing the need for invasive procedures. This research contributes to the growing body of evidence advocating for HRCT as the gold standard in ILD evaluation, improving early detection and patient outcomes.

KEYWORDS – nterstitial Lung Diseases, High Resolution Computed Tomography, Chest Xray, Chest Radiography, Autoimmune Lung Diseases.

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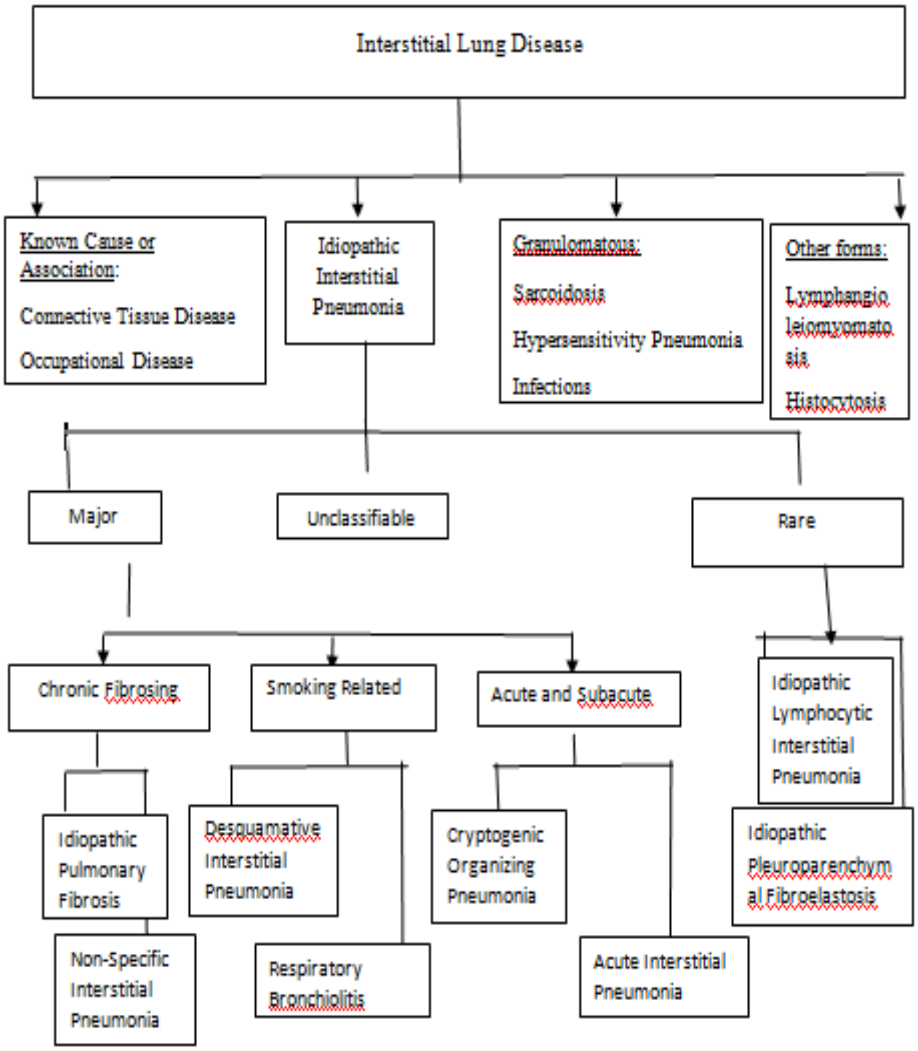
INTRODUCTION

The term ‘‘interstitial lung disease’’ is synonymous with ‘‘diffuse parenchymal lung disease’’[1]. Interstitial lung diseases are a group of diffuse parenchymal lung disorders associated with substantial morbidity and mortality.[2]The American Thoracic Society and European Respiratory Society define ILD as a heterogeneous group of non-neoplastic disorders resulting from damage to the lung parenchyma by inflammation and fibrosis that diminish the lung’s capacity for alveolar gas diffusion.[3]

CLASSIFICATION OF ILD [4,5]



ROLE OF IMAGING IN DIAGNOSIS:

Imaging plays a key role in the diagnosis and assessment of interstitial lung disease (ILD). Multidisciplinary team with expertise in ILD can often reach a reliable diagnosis based on clinical finding and radiology alone, as exemplified by the Join Consensus International Societies Statement on the classification of idiopathic interstitial pneumonias.[6]

CHEST RADIOGRAPHS:

- Chest radiography is typically the first radiological investigation requested and is frequently the initial indicator of ILD.
- It can be crucial to compare a patient's current chest radiograph with their prior ones in order to detect radiological anomalies and validate the existence of a progressing lung disease.
- Chest radiography may help exclude oedema or infection and can screen for complications, including malignancy. Typical findings in idiopathic pulmonary fibrosis include reticulations and reduced lung volumes.

HIGH RESOLUTION COMPUTED TOMOGRAPHY:

- The latest clinical guidelines from the American Thoracic Society and European Respiratory Society recommend HRCT as a more sensitive tool for detecting ILD compared to chest radiography or conventional chest CT, making it essential for diagnosing ILD. [7,8]
- High resolution computed tomography is now a standard investigation in patients with suspected interstitial lung disease.
- HRCT plays a key role in identification of the pathological phenotype of ILD, and typical imaging features are well recognised in international consensus guidelines.[3]

- HRCT can also aid in distinguishing between various types of ILDs, including subclassifying CTD-ILDs and differentiating between early and progressive stages of the disease. [9-11]

HRCT IN PROGNOSIS:

- Beyond diagnosis, HRCT is valuable for assessing prognosis in ILDs. The extent of honeycombing and reticulation can help predict mortality risk in IPF patients.
- Assessing fibrosis extent can suggest a poor prognosis for patients with fibrotic ILDs, even in cases of fibrotic IIP with minimal honeycombing. [12,13]

MAGNETIC RESONANCE IMAGING:

- Combining functional and morphological information, MRI has been arising as a radiation-free alternative, comparable to CT in many instances.[14,15]
- The presence of high signal intensity lesions has been reported as a helpful predictor of treatment response and prognosis.[16]
- Drawbacks with MRI is that it has a poor signal-to-noise ratio in the lung and are currently overshadowed by HRCT as the imaging technique of choice for ILD diagnostic and prognostic purposes.[17]

TRANSTHORACIC ULTRASOUND:

- While international guidelines do not define a specific role for TUS (transthoracic ultrasound) in evaluating ILDs (interstitial lung diseases), this imaging technique offers several advantages. It is non-invasive, safe, enables rapid real-time assessment, and is accessible for clinicians across all hospital wards.
- TUS can be valuable in identifying early lung involvement and monitoring ILD progression, serving as a timely prompt for follow-up chest CT scans when necessary.

MATERIALS AND METHODOLOGY

Study Design- Cross-Sectional Observational Study

Study Duration- 24 months from the approval of Ethical Committee.

Study Population- 100 patients.

Method

A prospective study was carried out at Parul Sevashram Hospital. Consecutive patients presenting with respiratory symptoms like cough, fever, difficulty in breathing, dyspnea on exertion, tachypnea and seeking medical advice for the same or have medical conditions due to such affliction will be included in the study after taking consent. 100 patients meeting the inclusion criteria were enrolled in the study. Written Informed consent was obtained from each patient.

Inclusion Criteria

- Patients of all ages were included.
- No gender bias.
- Patients presenting with signs and symptoms suggestive of Collagen Vascular Diseases like SLE, rheumatoid disease, systemic sclerosis, MCTD, UCTD, poly-derma.
- Patients of Pulmonary / Systemic vasculities like Wegener's granulomatosis, Churgg-Strauss syndrome, Microscopic polyangitis, Diffuse alveolar haemorrhage, etc.
- Patients with history of occupational exposure to asbestos, silica, coal dust, heavy metal exposure, aluminium, organic dust etc.
- Patients on pneumato-toxic drugs.
- Patients with exposure to radiotherapy.
- Patients with history of allergy.

Exclusion Criteria

- Known cases of pulmonary infections, pneumocystis carinii pneumonia, viral pneumonias.
- Known cases of pulmonary metastasis.
- Known cases of tuberculosis (except silico-tuberculosis).
- Known cases of lung masses.
- Known cases of lymphangitic carcinomatosis.
- Pregnant females.
- Those who didn't gave consent.

TECHNIQUE:
All patients were subjected to chest X ray & followed by HRCT thorax, at the same time using:

1. X ray machine – GE X Ray Machine
2. Toshiba Alexion 16 slice CT scan machine.

CHEST X RAY TECHNIQUE:
PA view was taken in full inspiration.

SCANNING PARAMETERS:

- **POSITION**: Supine, Prone
- **SCANNER SETTINGS**: kV (p)-120, mAs (effective)-100-200 or dynamic
- **COLLIMATION:** 1 mm
- **SCAN TIME**: 60-90 sec
- **MATRIX SIZE**: 512 x 512
- **SUPERIOR EXTENT**: Lung apices.
- **WINDOW SETTINGS:** Lung window and Mediastinal window.
- **SLICE THICKNESS:** 0.625-1.25 mm
- **FOV:** 35 cm
- **RECONSTRUCTION ALGORITHM:** High spatial frequency

HRCT THORAX TECHNIQUE:

- 1 mm collimation sections were obtained. Five to eight slices with thincollimation were obtained at different anatomic levels of the lung. 2 cm or 3 cm

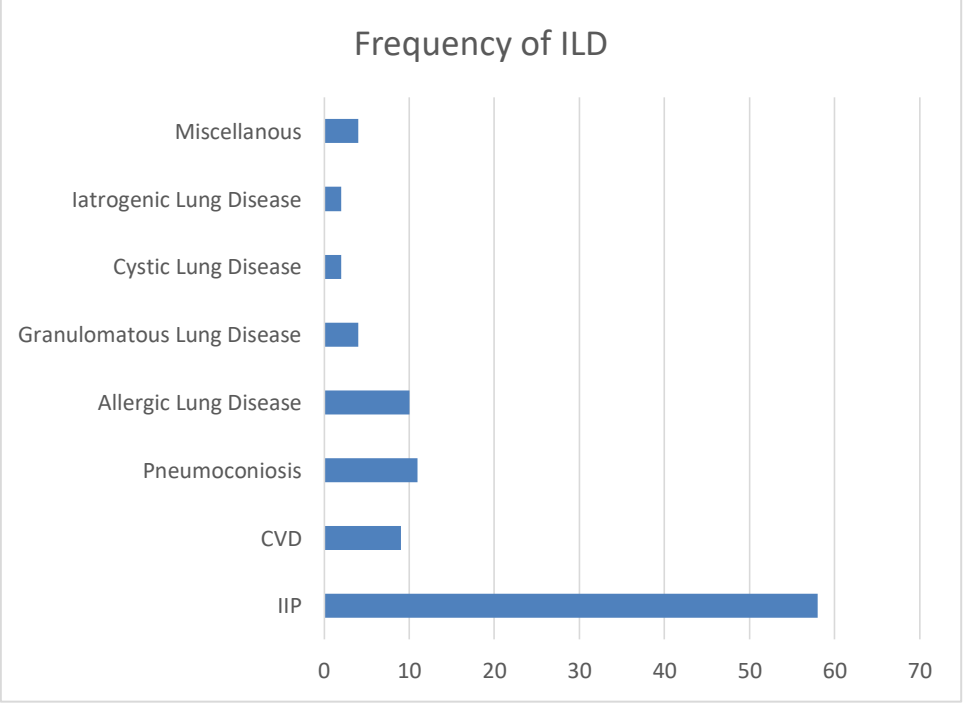
intersection gap was used. Scanning was performed using a field of view large enoughto encompass both lungs (35-40cm).

- Retrospective targeting of the imagereconstruction to a single lung or an even smaller portion of the lung parenchyma was done for spatial resolution.
- Inspiratory and expiratory scans were taken in all patients.

OBSERVATIONS

The frequency of Idiopathic Interstitial Pneumonia was found highest among all types of Interstitial Lung Disease followed by Pneumoconiosis as shown in Chart 1.

Chart 1: Graphical Presentation of Frequencies of Interstitial Lung Disease

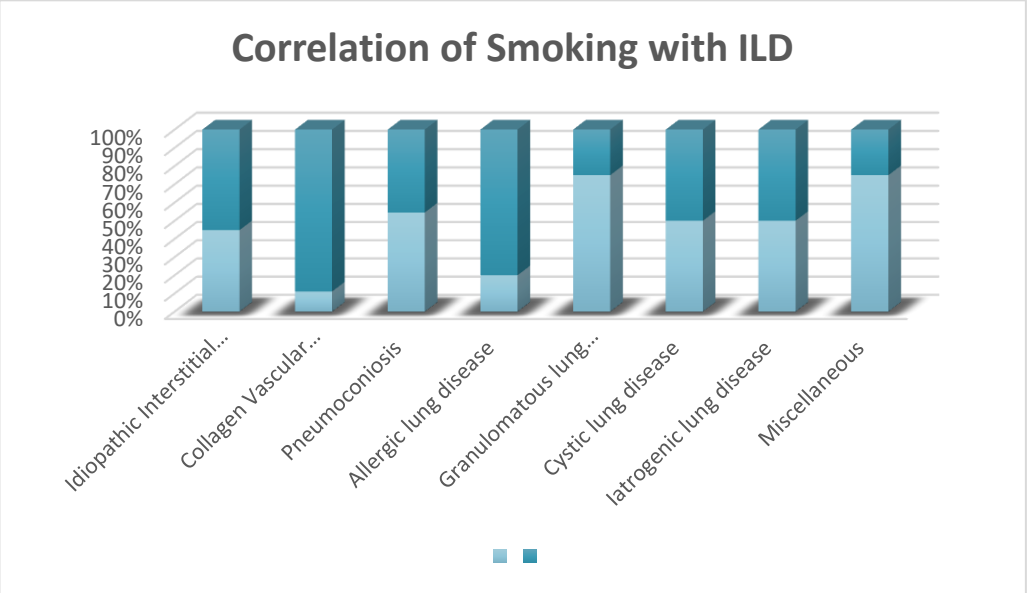


Age wise Distribution of 100 cases of Interstitial Lung Disease

- The most common age group of presentation for presentation of Interstitial Lung Disease is 51 to 70 years.

- Collagen Vascular Disease related ILDs were commonly seen in the age group of 41 to 60 years.
- LCH and LAM were seen at relatively younger age group of 21 to 30 years.

Chart 2: Graphical Presentation of Correlation of Smoking with Interstitial Lung Disease



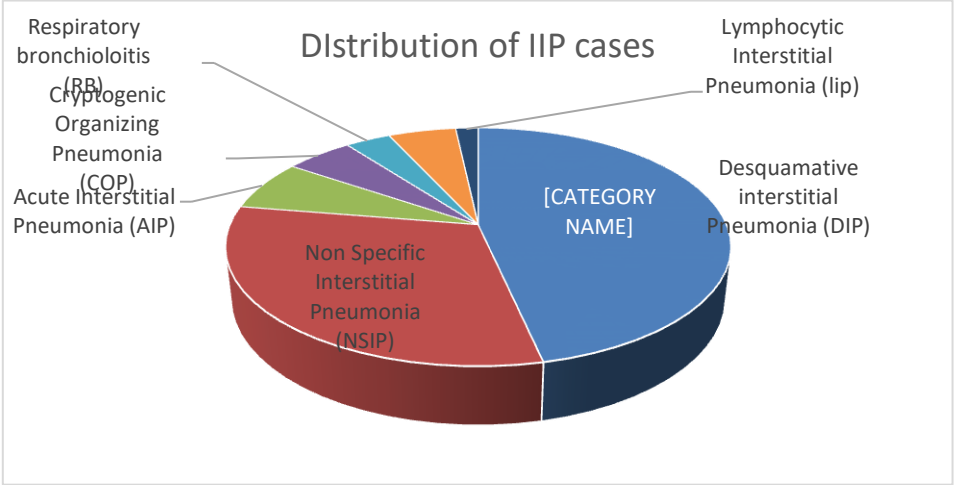
Smoking is a significant risk factor, with higher rates of lung disease observed in individuals with a history of smoking. The chart 2 illustrates the correlation between smoking and the prevalence or severity of interstitial lung disease.

Table: Distribution of Chest Radiograph and HRCT Thorax findings in 100 cases of ILD

MODALITY	POSITIVE FINDINGS	NORMAL	TOTAL
CHESTX-RAY	90	10	**100**
HRCTTHORAX	100	0	**100**

The table above shows that HRCT has more sensitivity and specificity in diagnosis of Interstitial Lung Disease.

Chart 3: Graphical Presentation of Distribution of cases of Idiopathic Interstitial Pneumonia



Highest Incidence of Usual Interstitial Pneumonia is seen among the distribution of Idiopathic Interstitial Pneumonia as illustrated in chart 3 above.

Chart 4: Graphical Presentation of Distribution of cases of Collagen Vascular Disease related ILDs

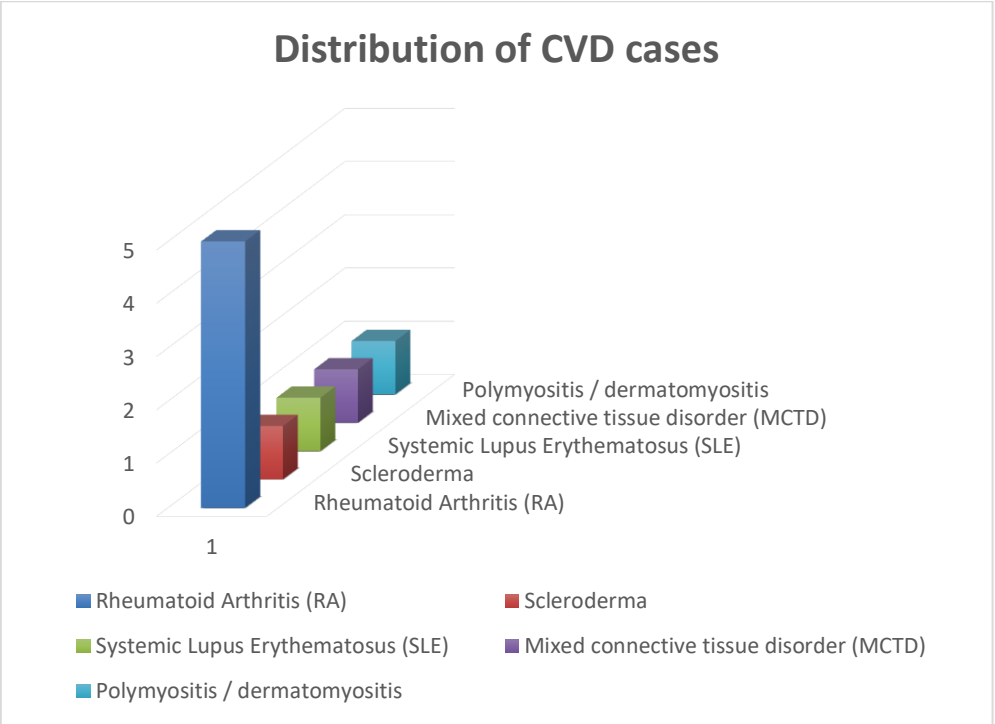
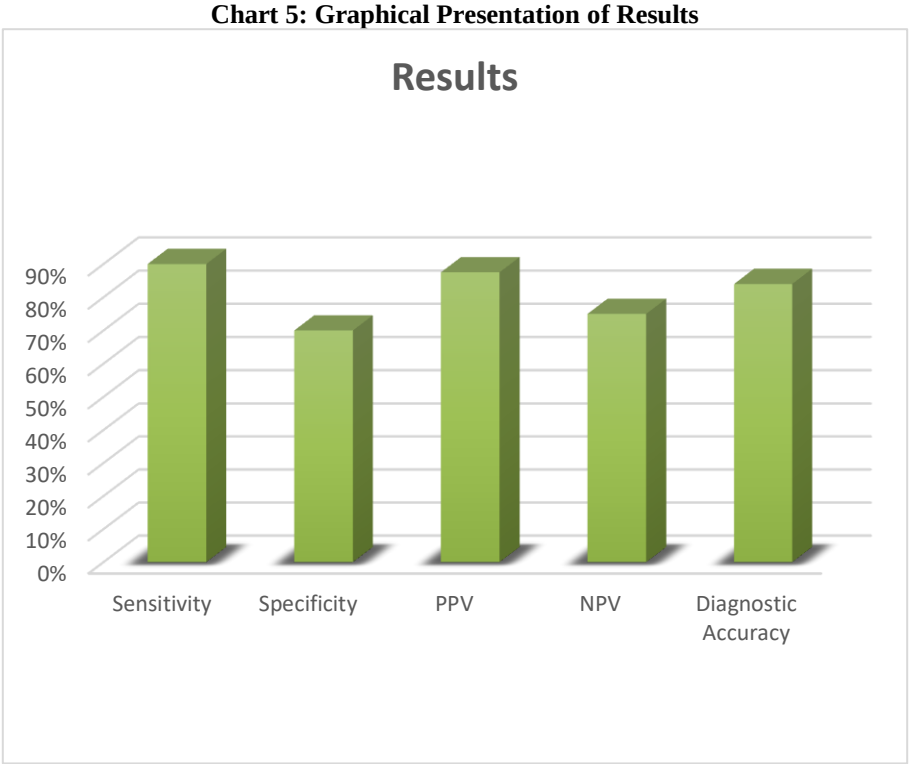


Chart 4 shows distribution of cases of Collagen Vascular Disease with highest incidence of Rheumatoid Arthritis.

RESULTS

100 patients were included in the present study with mean age of 56.79±13.47. The results of the study were analyzed in the terms of Sensitivity, Specificity, Positive Predictive value, Negative Predictive value and Diagnostic Accuracy as shown in Chart 5.

Chart 5: Graphical Presentation of Results



The diagnostic performance metrics for comparing Chest X-Ray and HRCT in the diagnosis of Interstitial Lung Disease (ILD) were evaluated, yielding insightful results. The sensitivity of HRCT was found to be notably high at 90%, indicating its effectiveness in correctly identifying true positive cases among individuals with ILD. However, specificity was observed to be 70%, suggesting a moderate ability to accurately classify true negative cases. The Positive Predictive Value (PPV) and Negative Predictive Value (NPV) were calculated at 87.5% and 75%, respectively, underscoring the reliability of HRCT in predicting the presence or absence of ILD. Overall accuracy was found to be 84%, reflecting the combined efficacy of HRCT in correctly classifying both positive and negative cases as found in chart 5.

DISCUSSION

The findings of this study reveal a noteworthy difference in diagnostic accuracy between HRCT and chest X-ray in the context of ILD.The identification of interstitial lung disease (ILD) is frequently delayed due to the oversight of clinical observations, with respiratory symptoms often attributed to more prevalent pulmonary conditions like chronic obstructive pulmonary disease (COPD) in primary care. For individuals experiencing progressive dyspnea, it is crucial to consider ILD as a potential diagnosis since this symptom is a common complaint among ILD patients.[18]

Plain CXR is considered as baseline investigation in patients with respiratory symptoms. Chest X-ray (CXR) is a readily accessible, cost-effective, and non-invasive diagnostic tool; however, it fails to detect abnormalities in 20% of patients. In the early stages of the disease, CXR may appear normal and might not effectively characterize Interstitial Lung Disease (ILD).[19]

HRCT of the lung is well-established in its role in formulating the initial diagnosis of ILD. However, its significance extends to monitoring of patients with serial examinations. HRCT is superior to plain radiography for various reasons. This longitudinal imaging data frequently furnishes substantial additional information compared to a single time point and can be utilized in various ways, including: 1) enhancing the accuracy of the initial diagnosis; 2) aiding in prognosis estimation; 3) recognizing disease progression; 4) detecting new developments in patients experiencing acute or worsening symptoms; and 5) identifying other abnormalities or complications, such as lung cancer[20]. In situations where biopsy may have been traditionally deemed essential, there has been a shift in perspective due to the advantages offered by HRCT.

USUAL INTERSTITIAL PNEUMONIA

The subpleural region in the lower lobes was frequently affected in all patients, suggesting a basal initiation of the disease that progressively involved the rest of the lungs. This finding is consistent with studies by Nakata et al[21] describing a basal predominance of the disease.Intra and interlobular interstitial thickening, resulting in a fine reticular pattern, was identified in all patients, primarily in subpleural locations. This thickening produced irregular interfaces between lung structures, pulmonary vessels, bronchioles and pleura. Webb W.R[22] also described thickened interlobular septae with irregular contours.

NON-SPECIFIC INTERSTITIAL PNEUMONIA

CT findings of NSIP differ from those of UIP. Multivariate logistic regression analysis indicated that the most useful distinguishing factor between UIP and NSIP is honeycombing[23]. In UIP, honeycombing was observed in 85.18% cases, compared to 12.5% in NSIP in our study, consistent with the literature.Another crucial feature distinguishing NSIP from UIP is the temporal uniformity in NSIP.Although the extent of inflammation and fibrosis may vary in NSIP, the entire process tends to manifest symptoms that develop simultaneously

ACUTE INTERSTITIAL PNEUMONIA

In the current study, a total of 5 patients tested positive, with 3 being male and 2 female. Conventional chest radiographs revealed bilateral air-space consolidation in all 5 patients (100%) and ground glass opacity in 4 out of 5 patients (80%), consistent with the findings of Primack et al.[24].All 5 patients exhibited extensive bilateral symmetrical areas of consolidation and ground glass, primarily distributed para-hilarly and diffusely involving bilateral lung fields. These observations align with the research conducted by Johkoh et al.[25], who demonstrated similar extensive ground glass opacity and consolidation in 92% of patients, accompanied by architectural distortion, traction bronchiectasis, thickening of peribronchovascular bundles, and interlobular septal thickening.

CRYPTOGENIC ORGANISING PNEUMONIA

Conventional chest radiographs revealed asymmetrical, randomly distributed areas of ground glass opacity (GGO) and consolidation in all patients. High-resolution computed tomography (HRCT) demonstrated patchy consolidation with internal GGO areas in the lung fields, aligning with the findings reported by Muller et al.[26].

RESPIRATORY BRONCHIOLITIS

Three male patients with RB-ILD were identified, all of whom were smokers.air trapping and emphysema were evident in all three patients, indicating changes associated with smoking-related small airway disease.

DESQUAMATIVE INTERSTITIAL PNUEMONIA

The HRCT results for our patients revealed numerous patchy areas of ground glass opacity (GGO) with regions of air

trapping, particularly noticeable on expiratory scans. These findings were diffusely distributed in bilateral lung fields, with a predominant involvement of the bilateral upper lobes, suggesting alterations indicative of both obstructive and infiltrative lung diseases. Our observations aligned with a study conducted by Johkoh et al.[27]

LYMPHIOD INTERSTITIAL PNEUMONIA

The conventional chest radiograph revealed nodular opacities and a reticulo-nodular pattern in both lungs. The HRCT thorax exhibited widespread bilateral areas of ground glass opacity (GGO), poorly defined centrilobular nodules, thickening of the peribronchovascular interstitium, and mediastinal lymphadenopathy

RHEUMATOID ARTHRITIS

In RA patients exhibiting a UIP pattern on HRCT scans, a confident diagnosis of RA-ILD with UIP pattern can be established. Likewise, the HRCT thoracic scan manifestation of isolated ground-glass opacities (GGO) without honeycombing or reticulation appears to correspond well with histologic NSIP.

SCLERODERMA

Conventional chest radiographs displayed a bilateral symmetrical reticular/reticulonodular pattern, accompanied by ground-glass opacities (GGO), predominantly in the lower zones. According to Webb[29], NSIP is the most prevalent pattern of ILD associated with scleroderma, followed by usual interstitial pneumonia (UIP) and cryptogenic organizing pneumonia (COP). Our observation of esophageal dilatation in scleroderma case aligns with the findings reported by Remdy Jardin et al.[30].

SYSTEMIC LUPUS ERYTHEMATOSUS

The chest radiograph revealed localized regions of consolidation and ground-glass opacities (GGO). High-resolution computed tomography (HRCT) of the thorax demonstrated randomly dispersed areas of consolidation with GGO in both lungs, indicative of changes consistent with organizing pneumonia (OP).

POLYMYOSITIS-DERMATOMYOSITIS (PM-DM)

The thoracic high-resolution computed tomography (HRCT) results indicated findings consistent with an organizing pneumonia (OP) pattern.

COAL WORKER'S PNEUMOCONIOSIS

In all cases, the predominant pattern of involvement was parenchymal nodules. These nodules were predominantly centrilobularly and subpleurally, exhibiting a diffuse and bilateral distribution. These findings align with the research conducted by Remy-Jardin M[30], who identified nodules as the predominant feature in 81% of cases.

SILICOSIS

In all patients, the predominant pattern of involvement was characterized by nodules. These nodules were mainly centrilobular and subpleural, exhibiting bilateral distribution with a predominance in the upper lobes. These findings align with the research conducted by Anatao VC et al.[31].

HYPERSENSITIVITY PNEUMONITIS

In this study, 8 patients exhibited ground glass opacities without fibrosis or architectural distortion, aligning with the subacute stage of the disease as described by Matar et al[31] and Silber et al. On the other hand, one patient demonstrated ground glass opacities with superimposed fibrosis and architectural distortion, indicative of the chronic stage of the disease, as reported by Matar et al and Silva CIS et al[32,33].

SIMPLE PULMONARY EOSINOPHILIA/LOEFFLER'S SYNDROME

The conventional chest radiograph revealed patchy areas of consolidation and ground-glass opacities (GGO) randomly distributed in both lung fields.HRCT of the thorax demonstrated patches of consolidation with peripheral ground-glass opacities (Halo sign) located peribronchially and subpleurally in both lungs. Additional observations included peribronchial thickening associated with areas of air trapping. These findings align well with those described by A. Bernheim and T. McLoud.[34]

SARCOIDOSIS

Multiple patches of ground-glass opacity (GGO) and lucency, leading to mosaic attenuation, were observed diffusely in bilateral lung fields. These areas of GGO, along with air trapping and oligemia on expiratory scans, were consistent with the findings of Muller NL et al.[35], who demonstrated focal or patchy GGO on high-resolution computed tomography (HRCT) superimposed on a background of interstitial nodules or fibrosis.

LANGERHANS CELL HISTIOCYSTOSIS

The HRCT scan revealed peculiarly shaped and asymmetric cysts in both lungs, with a notable sparing of the lower lobes bilaterally. Additionally, centrilobular parenchymal nodules were identified. These cysts were present in 80% of cases,

and nodules were present in 60 to 80% of cases, as reported in a study by Fraser RG[36].

LYMPHANGIOLEIOMYOMATOSIS

The HRCT characteristics comprised numerous round, thin-walled cysts distributed diffusely throughout all lobes of both lungs. The lung parenchyma between these cysts appeared normal. These observations were in line with the findings reported by Bonelli F S et al[37] and Rapport D C et al[38].

SUMMARY AND CONCLUSION

In the present study, HRCT yielded positive results in all cases, contrasting with X-ray, which showed positivity in 95% of cases. HRCT demonstrated higher diagnostic efficacy compared to the conventional chest radiograph, where a nonspecific reticular or reticulonodular pattern was predominantly identified. Beyond enhancing detection, HRCT allowed for a more detailed visualization of various interstitial lung disease patterns.It is capable of identifying disease processes at earlier stages than both chest radiographs and conventional CT scans in some instances. Furthermore, HRCT exhibited a notable absence of significant inter-observer variability as observed in interpretation of chest radiographs.

The study's outcomes have significant implications for clinical practice, emphasizing the need to reconsider the role of chest X-ray as the primary imaging modality in suspected ILD cases. Integrating HRCT early in the diagnostic algorithm can expedite accurate diagnoses, facilitating prompt initiation of appropriate therapeutic interventions.

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