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EVALUATION OF DIFFUSE PARENCHYMAL LUNG DISEASES BY HIGH RESOLUTION COMPUTED TOMOGRAPHY OF CHEST

Radio-Diagnosis

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ABSTRACT

Introduction: Diffuse parenchymal lung diseases (DPLD) historically referred to as interstitial lung diseases (ILD), encompass a wide range of lung disorders characterized by inflammation and scarring of the lung tissue. These conditions involve the entire pulmonary parenchyma including alveolar walls and interstitium, leading to progressive impairment in the lung function. **Aim:** To evaluate different diffuse parenchymal lung diseases by high resolution computed tomography (HRCT) and correlating with spirometry. **Methods:** A cross-sectional observational study was conducted in the Department of Radiodiagnosis, Silchar Medical College and Hospital, Silchar on 60 patients with a suspected diagnosis of DPLD referred by Departments of Medicine and Pulmonary Medicine, Silchar Medical College, for a period of 1 year. **Results:** The majority of the patients (n=22; 36.37%) were between the ages of 52-60 years, with male preponderance (n=34; 56.67%). The most common clinical complaint was dyspnoea (n=45: 75%). The most common diffuse parenchymal lung disease in our study was usual interstitial pneumonia (n=25; 47%), followed by non specific interstitial pneumonia (n=12; 20%) and connective tissue related ILD (n=5; 8.33%). On spirometry, the most common finding was a restrictive pattern (n=43; 71.67%). **Conclusions:** UIP was the most common DPLD observed in our study. Any patient suspected of having ILD should undergo an HRCT scan to confirm the diagnosis. HRCT is a non-invasive imaging technique with its high spatial resolution makes it more effective than other imaging methods. The various HRCT findings and their specific locations within the lung often allow for a precise diagnosis of ILD, potentially eliminating the need for a lung biopsy.

KEYWORDS

High resolution computed tomography, Usual Interstitial Pneumonia, Non-specific Interstitial pneumonia, honeycombing, Ground-glass opacities.

INTRODUCTION:

Diffuse parenchymal lung diseases (DPLD) encompass a wide range of lung disorders characterized by inflammation and scarring of the lung tissue. These conditions involve the entire pulmonary parenchyma including alveolar walls and interstitium, leading to progressive impairment in lung function.

Classification: The classification system for idiopathic interstitial pneumonias, developed by the "American Thoracic Society (ATS)/European Respiratory Society (ERS) consensus was initially published in 2002 and classified these disorders into 4 broad categories"(1).

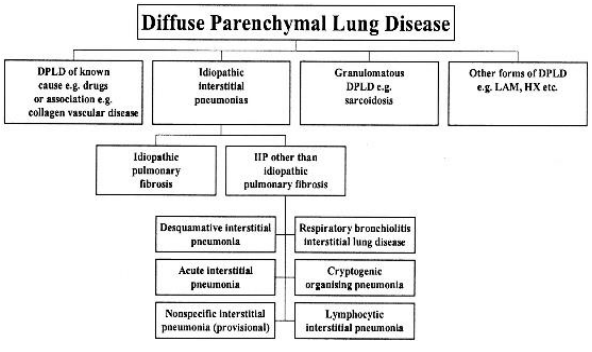


Fig 1: Flow chart showing classification of diffuse parenchymal diseases

Etiologies:

Known causes of DPLD

Drugs

Bleomycin, Methotrexate
Amiodarone
Nitrofurantoin, Sulphasalazine
NSAIDS like aspirin, ibuprofen, diclofenac, indomethacin

Systemic Diseases

Rheumatoid Arthritis
Systemic Lupus Erythematosus
Sjogren's syndrome
Ankylosing Spondylitis
Wegener's granulomatosis
Good pasture's syndrome
Microscopic polyangitis

Inherited disorders like "tuberous sclerosis, Lipid storage disorders Neurofibromatosis, Hermansky-Pudlak syndrome" etc.

Occupational / environmental exposure

Asbestosis: Caused by inhalation of asbestos fibres
Silicosis: Resulting from inhalation of silica dust
Coal Workers' Pneumoconiosis: Caused by inhalation of coal dust
Farmer's lung (thermoactinomycetes in mouldy hay).
Bird fanciers' lung
Fungi- Suberosis
Bagassosis- (thermoactinomycetes in mouldy sugarcane)

Idiopathic interstitial pneumonia (IIP)

Usual interstitial pneumonia (UIP)
Non-specific interstitial pneumonia (NSIP)
Acute interstitial pneumonia (AIP)
Respiratory bronchiolitis- interstitial lung disease (RB-ILD
Desquamative interstitial pneumonia (DIP)
Cryptogenic organizing pneumonia (COP)
Lymphocytic interstitial pneumonia (LIP)

Granulomatous Diseases

Sarcoidosis
Wegener's granulomatosis
Churg Strauss syndrome

Rare forms of diffuse lung diseases
Lymphangiomyomatosis(LAM)
Langerhans cell histiocytosis (LCH)
Eosinophilic pneumonia
Alveolar proteinosis

DPLDs can be categorized into several major groups based on their underlying causes and histopathological features. The clinical presentation can vary widely depending on the specific type of DPLD and the extent of lung involvement. Most patients are middle-aged and usually present with progressive dyspnoea and a dry, non-productive cough. In advanced stages, they may experience respiratory failure. These conditions are typically chronic, with durations ranging from some months to several years.(2). The pathogenesis of DPLDs typically involves an aberrant wound healing response following lung injury. This results in excessive deposition of extracellular matrix and fibrosis, disrupting the normal lung architecture and impairing gas exchange(3). In patients with DPLD, lung function tests often indicate a restrictive pattern, evidenced by reduced "forced vital capacity (FVC) and total lung capacity (TLC)." Additionally, the "diffusing capacity for carbon monoxide (DLCO)" is typically decreased, reflecting impaired gas exchange caused by interstitial thickening and fibrosis(4).

The proposed study aims to assess the role of HRCT in diagnosing various diffuse parenchymal lung diseases and to correlate the range of findings with functional impairment as measured by spirometry, wherever applicable.

METHODS:

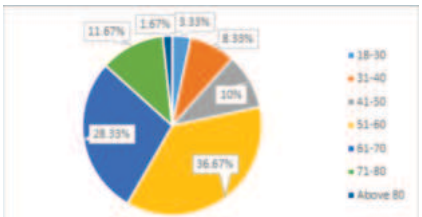
The study was a hospital-based cross-sectional observational study conducted from March 2023 to February 2024. A total of 60 patients above 18 years of age were studied, who were clinically suspected to have DPLD referred from both the outpatient department (OPD) and inpatient sections of the Departments of Medicine, and Pulmonary Medicine of our institute. Pregnant patients and known cases of infective causes (Tuberculosis, HIV etc), airway diseases (emphysema, asthma, COPD, etc) and hemodynamically unstable patients were excluded. Detailed proforma was filled and informed consent was taken from the subjects or their respective attendants after a thorough explanation of the procedure along with a detailed history, and a physical examination was conducted. Relevant laboratory investigations and chest radiographs findings were also noted. HRCT scan of the chest was performed on Phillips Ingenuity Elite / 128 slices MDCT scanner in supine position using a narrow slice thickness of 1cm with an interslice distance of 1 cm from the lung apices to the lung bases. A high spatial resolution image reconstruction algorithm was used, with a window level of -650 HU and a window width of +1500 HU. Prone positioning was employed to distinguish gravity-dependent atelectasis in the lung bases seen on supine images from early changes of idiopathic lung fibrosis. A pulmonary function test was done in the Department of Medicine using spirometry, Forced vital capacity (FVC) and forced expiratory volume (FEV) in one second were measured and the FEV1/FVC ratio was calculated. Parenchymal abnormalities were classified based on HRCT patterns, their distribution, and predominant involvement. The final possible diagnosis was determined according to HRCT findings and clinical information.

Statistical Analysis:

Data were entered into Microsoft Excel 2013, and statistical analysis was performed using SPSS version 28.0. Quantitative data were presented using mean and standard deviation, while qualitative variables were summarized using frequencies and percentages.

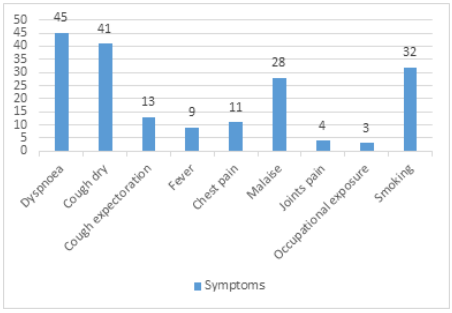
RESULT:

Out of 60 patients, most of them belonged to the age group 51-60 years (n=22; 37.67%) with male preponderance (n=34; 56.67%). The mean age was found to be 57.23 +/- 13.7 years. (Graph 1)



Graph 1: Age distribution of cases

The most common clinical complaint was dyspnoea (n=45: 75%). The next common symptom was dry cough and was found in 41 patients (68.33%). This was followed by malaise and chest pain accounting for 46.67% and 18.33% respectively. Some patients has also varying symptoms like fever, cough with expectoration, joints pain, tight skin etc. Positive occupational exposure was found in 3 patients (5%) and 32 (53.33%) have a history of smoking. (Graph 2)



Graph 2: Distribution of clinical symptoms in DPLD

In our study, the most common HRCT pattern was reticular opacities, observed in 48 cases (80%). This was followed by traction bronchiectasis/bronchiolectasis in 42 cases (70%), and ground-glass opacities in 40 cases (60.67%). Honeycombing was noted in 28 cases (46.67%), while mediastinal lymphadenopathy was seen in 24 cases (40%). Emphysematous changes were present in 19 cases (31.67%), pleural thickening in 34 cases (56.67%), and architectural distortion in 26.67%. Cystic changes were observed in 8.33%, bronchial wall thickening and mosaic attenuation in 5% each, and pleural effusion in 2 cases (3.33%).

Usual Interstitial Pneumonias were the most common diffuse parenchymal lung diseases comprising 27(45%) of the 60 cases, followed by Non-specific interstitial pneumonia n=12 (20%), connective tissue disease related ILD n=5(8.33%), Occupational lung disease n=4(6.67%), Respiratory bronchiolitis-ILD n=3(6.67%), hypersensitivity pneumonitis n=3 (5%), 2 cases (3.33%) each of cryptogenic organising pneumonia and lymphangioleiomyomatosis, and 1 case (1.67%) each of drug induced ILD and combined pulmonary fibrosis and emphysema.(Table 1)

Table 1: Gender wise distribution of various DPLD

	Male	%	Female	%	Total
Usual Interstitial Pneumonia	19	31.67	8	13.33	27
Non-specific Interstitial Pneumonia	4	6.67	8	13.33	12
Hypersensitivity pneumonitis	1	1.67	2	3.33	3
Occupational lung diseases	4	6.67	0	0	4
Cryptogenic organizing Pneumonia	1	1.67	1	1.67	2
Respiratory bronchiolitis-ILD	3	5	0	0	3
Connective tissue disease- ILD	0	0	5	8.33	5
Drug-induced ILD	1	1.67	0	0	1
Combined Pulmonary fibrosis and emphysema	1	1.67	0	0	1
Lymphangioleiomyomatosis (LAM)	0	0	2	3.33	2
Total	34	56.67	26	43.33	60

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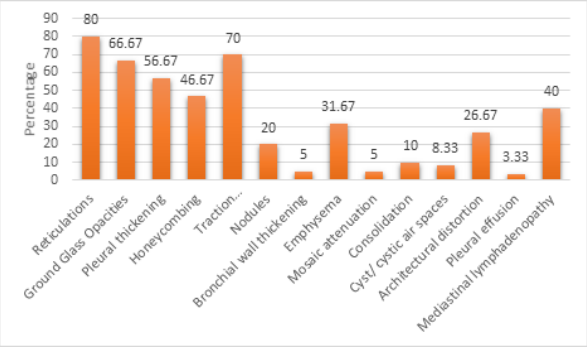
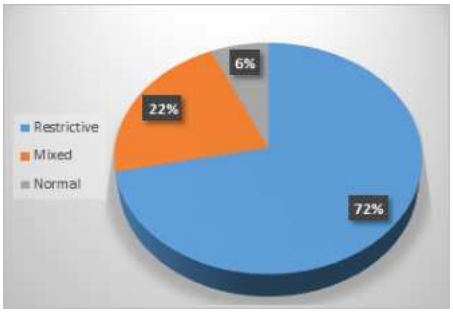
Cystic changes were observed in 8.33%, bronchial wall thickening and mosaic attenuation in 5% each, and pleural effusion in 2 cases (3.33%). (Graph 3)



Graph 3: Distribution of HRCT findings.

Diffuse involvement is seen in 27 cases (45%), 25 cases (41.67%) had a lower lobe predominance and an upper lobe predominance is seen in 8 patients (13.33%). Diffuse involvement is seen as commonest in NSIP, HP, COP, and LAM whereas lower lobe predominance is common in UIP.

The most common spirometry finding was a restrictive pattern, observed in 43 patients (71.67%). Additionally, 13 patients (21.67%) exhibited a mixed pattern, while 4 patients (6.66%) had normal spirometry results. (Graph 4). Mean value of FEV1 %, FVC% and FEV1/FVC ware 70.72+16.03, 62.08+13.58 and 89.52+11.62 respectively.



Graph 4: Distribution of spirometric patterns.

DISCUSSION:

This study aimed to assess the clinical and radiological profiles of diffuse parenchymal lung diseases (DPLD) using high-resolution computed tomography (HRCT) in our hospital setting. We included 60 patients who were clinically suspected of having DPLD and referred for HRCT of the thorax. Diagnoses were finalized based on clinical and radiological findings, with other potential conditions being ruled out.

In our study, the most prevalent diffuse parenchymal lung disease was usual interstitial pneumonia (UIP), accounting for 47% of cases. This was followed by nonspecific interstitial pneumonia (NSIP) in 12 cases (20%), connective tissue disease-related ILD in 5 cases (8.33%), and occupational lung disease in 4 cases (6.67%). Hypersensitivity pneumonitis and respiratory bronchiolitis-ILD were each reported in 3 cases (6.67%), while cryptogenic organizing pneumonia and lymphangioleiomyomatosis each had 2 cases (3.33%). Drug-induced ILD and combined pulmonary fibrosis and emphysema were each noted in 1 case (1.67%).

These findings are consistent with studies by Sen T Udwadia ZF et al(5), Kumar D et al(6), Bjoraker JA et al(7), Flaherty KR et al(8) and Hyldgaard et al(9) where UIP/IPF was the most commonly reported ILD. Notably, no cases of sarcoidosis were observed, which may be attributed to the small sample size and regional variations. Comparisons with different studies are summarized in the table below.

Age Distribution

Our study focused on patients over 18 years of age, with the oldest being 84 years and the youngest 21 years. Most patients were in the 51 to 60 years age group (36.67%), followed by 17 cases (28.33%) in the 61–70 years range. The mean age was 57.23±12.96 years, indicating a predominance of older patients. These findings are consistent with studies by Singh and Collins et al (2016)(10), Sreekala C et al (2017)(11) and Kumar et al (2020)(6)

Gender Distribution

Our study observed a male predominance (56.67%), which aligns with previous studies by Coultas et al (1994)(12) and Bjoraker et al (1997)(7), Kumar et al (2020)(6). However, Singh et al(10) reported a higher incidence of ILD among females (50.8%), which may be attributed to a larger proportion of collagen vascular diseases in their study compared to the 8.33% seen in our study

Presenting Complaints Of Patients

In our study, the majority of the patients presented with dyspnoea (75%) followed by cough in 68.33%. This is similar to the study conducted by Muhammed et al(13) and Doshi et al(14). In previous study conducted by Sen et al(5), Gagiya et al(15), Jindal et al(16), and Nipun et al(17), breathlessness presentation was 100%, while in studies by Kumar et al(6), it was 92%,

Lobar Distribution Of Hrct Findings

In our study, diffuse involvement was seen in 27 cases (45%), 25 cases (41.67%) had a lower lobe predominance and an upper lobe predominance is seen in 8 patients (13.33%). A study done by Dhooria S et al(18) observed lower lobe predominant in 34.5% followed by diffuse involvement in 31% and upper lobe predominance in 21.7%. Lower predominance is also observed by Annapurna et al(19).

HRCT findings

In our study, reticular opacities were the most common finding, seen in 80% of cases, followed by traction bronchiectasis/bronchiolectasis and ground-glass opacities. This is similar to the study by Zerhouni et al(20), where 89% of cases showed reticular opacities. Additionally, 66.6% of cases in our study exhibited ground-glass opacities, compared to 54% reported by Leung An et al(21) noted it in 54% cases. Previous studies on ILD consistently identify reticular opacities as a prevalent HRCT finding, as noted in Leslie KO et al(22), Patil et al, Elicker B et al(23).

Usual Interstitial Pneumonia/idiopathic Pulmonary Fibrosis:

In the present study, usual interstitial pneumonia (UIP) was the most common pattern, observed in 27 cases (45%), with 19 males (31.67%) and 8 females (13.33%).

HRCT revealed that the posterior basal and subpleural areas were most affected (100%). Diffuse involvement with an apico-basal gradient was noted in 44.4% of cases, indicating that the disease typically starts in the posterior basal regions and progresses to the upper lung areas. These observations are consistent with the findings of Lim MK et al(24) and Battista G et al(25).

Reticulations were present in all patients (100%), and honeycombing was observed in 92.57%, predominantly in the subpleural and basal regions. These findings are consistent with the results reported by Nishiyama O et al(26).

Non Specific Interstitial Pneumonia

In our study of non-specific interstitial pneumonia (NSIP) (n=12), the most prevalent HRCT findings were reticular opacities and ground-glass opacities, observed in all cases (100%). Traction bronchiectasis was noted in 10 cases (83.33%), and most cases (83.33%) exhibited subpleural sparing. Additionally, microcystic changes and mediastinal lymphadenopathy were observed in 3 cases (25%) and 9 cases (75%), respectively. These findings align with the studies by Palmucci S et al(27) and Elicker B et al(23) which highlight reticulations and ground-glass opacities as predominant features in NSIP. Kim et al(28) also reported that subpleural predominance was commonly observed and that ground-glass opacities on CT correlated with interstitial thickening due to inflammation and fibrosis.

Connective tissue diseases related ILD

In our study, we identified five cases of connective tissue diseases (CTDs): two cases of Rheumatoid Arthritis (RA), two cases of Systemic Lupus Erythematosus (SLE), and one case of Systemic Sclerosis (SS). All cases were diagnosed serologically.

The RA cases, all in females, exhibited a pattern of reticular opacities, honeycombing, and traction bronchiectasis associated with usual interstitial pneumonia (UIP), consistent with findings by JK Dawson et al(29), Biederer J et al(30) and Kinoshita et al(31).

Among the two SLE cases, one showed features of acute interstitial pneumonia, while the other displayed focal ground-glass opacity in the left lower lobe, indicating early inflammatory changes associated with SLE. These findings align with the studies by Fenlon HM et al(32) and Ooi GC et al(33). The second SLE case also showed pleural effusion, thickening of interlobular septa, and peribronchovascular interstitial thickening, as reported by Fenlon HM et al(34) and Ooi GC et al(33).

Additionally, one case (1.67%) of scleroderma, diagnosed serologically, showed a non-specific interstitial pneumonia (NSIP) pattern on HRCT, correlating with studies by Chan TY et al(35) and Fujita et al(36).

Hypersensitivity pneumonitis (HP)

The present study included 3 patients (5%) with hypersensitivity pneumonitis: 1 case (33.3%) of subacute type and 2 cases (66.6%) of chronic type, all with a history of exposure to poultry farming. In the 2 chronic cases, ground-glass opacities were observed, either patchy or diffuse. The middle lung zones and anterior parts were commonly affected, with relative sparing of the apical and basal regions, consistent with BD Adler et al(37). Fibrosis was noted in two patients, predominantly in subpleural and peribronchovascular areas with irregular patterns, correlating with findings by Zompatori M et al(38) and Bd Adler et al(37) and Hansell DM et al(39).

Occupational Lung Diseases

In our study, 4(6.67%) cases of occupational-related lung diseases were observed of which all are males.

Two cases of coal worker pneumoconiosis (CWP) (3.33%) were identified in the present study in patients with over 15 years of exposure to coal dust in coal mines. HRCT findings included multiple nodules predominantly in the upper lobes, a soft tissue conglomerate mass in the middle zones migrating towards the hila, indicating progressive massive fibrosis. Additionally, there was mild interstitial thickening in the subpleural regions and multiple enlarged discrete mediastinal lymph nodes measuring 8-15 mm in short axis. These findings are consistent with the complicated form of CWP described by Young et al(40)

Silicosis was identified in two cases (3.3%) involving individuals who had been engaged in sandblasting for over 15 years. The predominant findings included multiple nodular opacities mainly in the subpleural regions and upper and posterior zones, with one case exhibiting progressive massive fibrosis. Additionally, multiple calcified mediastinal lymph nodes were observed. These findings align with those reported by Marchiori E et al(41), and Singh et al(10).

Cryptogenic organising pneumonia/ bronchiolitis obliterans organising pneumonia: We observed two cases of cryptogenic organizing pneumonia (3.33%), with one case each in male and female patients. HRCT findings included ground-glass opacities and/or consolidative areas distributed along the bronchovascular bundles and subpleural regions. These findings are consistent with the studies conducted by Ju Won Lee et al(42), Jala-Palomares et al(43), and Tiralongo F et al(44). Additional findings noted in our study were pleural thickening and bronchiectasis, pleural effusion, and mediastinal lymphadenopathy noted in 1 case.

Respiratory bronchiolitis- ILD

In our study, 3(5%) cases of RB-ILD were seen, in which ground glass opacities, nodules and bronchial wall thickening are found in all cases n=3(100%), emphysematous changes noted in 2 patients (66.67%). All the patients have positive history of chronic smoking. These findings correlate well with Park JS et al(45) and Palmucci S et al(27) where predominant HRCT findings are, bronchial wall thickening, poorly defined centrilobular nodules and centrilobular emphysema.

In our study, we identified one case of drug-induced ILD in a male patient undergoing chemotherapy for testicular cancer. The primary findings included reticular opacities, patchy ground-glass opacities, and mild traction bronchiectasis, but no evidence of fibrosis. These findings align with Akira M et al. This is in accordance with the study done by Akira M et al(46) who reported diffuse or multifocal ground-glass opacities with intralobular interstitial thickening in cases of antineoplastic agent-induced pneumonitis. Whereas Cleverley et al(47) reported that only 45 % of drug-induced ILD patients observed in HRCT have histological confirmation.

In our study, we observed two cases of lymphangioleiomyomatosis (3.33%), both in females. The most common findings were multiple oval-shaped, well-circumscribed, thin-walled cysts, generally less than 2 cm in size, evenly distributed throughout bilateral lung fields. These findings are consistent with those reported with Lim et al(48), Gupta et al(49) and Sekimoto Y et al(50).

In 2005, Cottin et al(51) introduced the term "combined pulmonary fibrosis and emphysema (CPFE)" to describe a condition characterized radiographically by centrilobular and/or paraseptal emphysema in the upper lobes and pulmonary fibrosis (primarily IPF/UIP) in the lower lobes. Using these criteria, our study identified CPFE in one case (1.67%).

Spirometry Findings

In our study, most of the cases have restrictive patterns in spirometry (71.67%), while a mixed pattern was observed in 31.67% and normal in 6.66%. which is closely resembles studies done by Jindal et al(16) and Bjoraker JA et al(7), where a restrictive pattern was observed in 60.9% and 73% respectively.

The mean values of FEV1, FVC and FEV1/FVC in our study were 70.72±16.03, 62.08±13.58 and 89.52±11.62 respectively. Arcadu et al(52) reported a mean FVC% of 64.01±17.4 whereas Singh S et al(10) reported a mean FVC% of 57.1±25.2. FEV1/FVC ratio was > 60% in the majority of the cases in the present study and also in Mahashur et al(53) studies (94%). Dhooria S et al(18) also reported restrictive patterns as more common findings in spirometry but with a higher mean FVC% of 72.5±20.7.

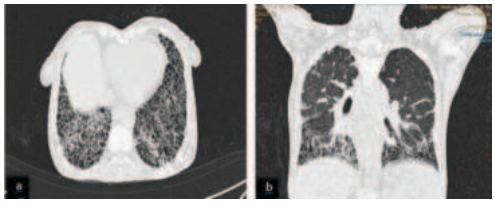


Fig 1: Axial (a) and coronal (b) HRCT section of lung window showing reticular opacities, diffuse fibrosis with septal thickening, honeycombing and apicobasal gradient. Findings are in favour of usual interstitial pneumonia.

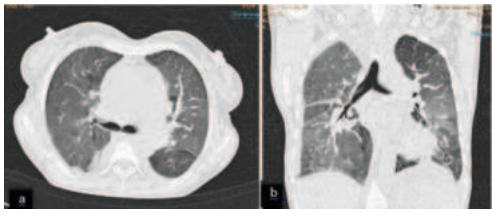


Fig 2: Axial (a) and coronal (b) HRCT section of lung window showing reticular opacities, with diffuse ground glass opacities. Findings are in favour of non-specific interstitial pneumonia.

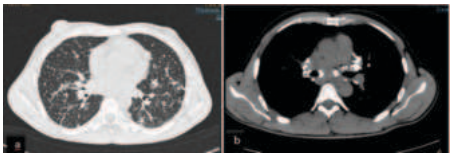


Fig 3: Axial lung window (a) and mediastinal window (b) HRCT section showing multiple centrilobular nodules with fine interlobular septal thickening and calcified hilar lymphnodes. Findings are in favour of silicosis.

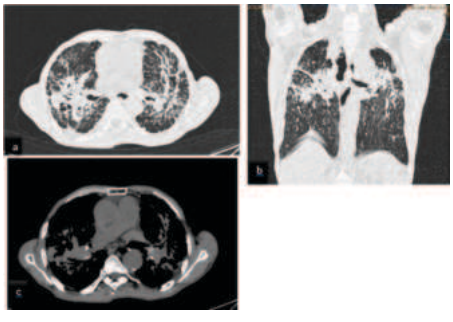


Fig: Axial(a) and coronal(b) section of lung window and axial section of mediastinal window (c) of HRCT showing extensive areas of perihilar consolidation, fibrosis, volume loss, and architectural distortion. Numerous fine nodules throughout both lungs and calcified mediastinal and hilar lymph nodes.

CONCLUSIONS:

Diffuse parenchymal lung disease encompasses a wide range of conditions that can show various, sometimes overlapping, findings on HRCT. Westernization has shifted the age distribution of diseases in the Indian population. For patients with worsening shortness of breath, interstitial lung disease (ILD) should be considered, as it's a common symptom in these cases. Any patient suspected of having ILD should undergo an HRCT scan to confirm the diagnosis.

HRCT is a non-invasive imaging technique used to assess lung parenchyma. Its high spatial resolution makes it more effective than other imaging methods. The various HRCT findings and their specific locations within the lung often allow for a precise diagnosis of ILD, potentially eliminating the need for a lung biopsy.

Spirometry is a simple, non-invasive method for evaluating the severity of ILD and provides an objective assessment without radiation risks. It is safe for pregnant patients and young children, and its lower cost makes it more accessible than HRCT. While HRCT is crucial for characterizing the disease, it does not assess lung function. Since spirometry measures often inversely correlate with HRCT findings in ILD, it serves as a practical alternative for assessing disease severity.

The results of this study are consistent with other studies that highlight the importance of High Resolution Computed Tomography (HRCT) as a standard tool for identifying and assessing the anatomical patterns and distribution of different parenchymal lung diseases.

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