Original article

Role of High Resolution Computed Tomography in Evaluation of Diffuse Parenchymal Lung Diseases

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ABSTRACT

Introduction : Diffuse parenchymal lung disease (DPLD) describes a heterogenous group of disorders of the lower respiratory tract characterized by inflammation and derangement of the interstitium and loss of functional alveolar units. The disease is not restricted to the interstitium, it involves the entire pulmonary parenchyma.The present study was undertaken to detect and study the profile of computed tomographic (CT) patterns of diffuse parenchymal lung diseases.

Methodology: The present study comprised of 60 patients of DPLD. Patients were evaluated by CT scan in Department of Radio-diagnosis from October 2014 to October 2016. Pregnant women and diagnosed cases of tuberculosis (sputum positive) were excluded .

Results: The most commonly identified diffuse parenchymal lung disease was idiopathic interstitial pneumonia (26.7%) followed by tuberculosis and post tubercular disease (16.7%) of the total cases.

Conclusion: Diffuse parenchymal lung diseases commonly occur in the middle age, the presenting complaint being unremitting dyspnea of long duration in most of the cases. Idiopathic interstitial pneumonia forms the major group of diffuse parenchymal lung diseases in our society. The extent and distribution of disease identified on HRCT scans correlates well with the clinical impairment.

INTRODUCTION

Diffuse parenchymal lung disease (DPLD) describes a heterogenous group of disorders of the lower respiratory tract characterized by inflammation and derangement of the interstitium and loss of functional alveolar units.The disease is not restricted to the interstitium as it involves epithelial, endothelial and mesenchymal cells with the disease process extending into the alveoli, acini and bronchioles. Thus, the entire pulmonary parenchyma is involved. Many acute and chronic lung diseases with variable degrees of pulmonary fibrosis have been described and commonly referred to as interstitial lung diseases. DPLD include a wide spectrum of diseases comprising more than 200 entities. Though the etiology may vary vastly, the clinical signs and symptoms differ little from one condition to another. The majority of patients are middle aged and present typically with progressive dyspnea and a dry unproductive cough.[1,2] When the rate of symptomatic progression in diffuse parenchymal lung disease is variable, the symptoms are usually chronic, ranging from few months to many years. Lung function tests typically show a reduction in the static lung volume, decreased pulmonary compliance and a reduction in diffusing capacity, which may vary. Radiological imaging plays an important role in the evaluation of DPLDs. Patients with suspected DPLD usually have a chest radiograph as the initial imaging investigation. In most cases, this is abnormal and occasionally the radiographic appearances are sufficiently characteristic to enable a specific diagnosis to be made in conjunction with the clinical and laboratory findings. The chest radiograph pattern is, however, not specific in most patients. Also, in a small proportion of patients with DPLD, the chest radiograph may be normal.

Conventional computed tomography of the chest provides a two dimensional representation of a three-dimensional cross-sectional slice of the lung. Although it allows assessment of the entire chest, it has limited ability to demonstrate fine parenchymal detail because all the structures within the thickness of the slice are averaged to produce the image.

High resolution computed tomography (HRCT) scanning is currently the most accurate non-invasive modality for

evaluating the lung parenchyma. It is capable of imaging the lung parenchyma with excellent spatial resolution and providing anatomical detail similar to that seen by gross pathological examination.[3] The modifications of the CT technique that make it one of "high resolution" are the use of thin sections and image reconstruction with a high spatial frequency algorithm. The added value of HRCT scanning in DPLD depends upon its ability to increase confidence of a specific diagnosis, to alter patient management and if possible, to influence outcome. However, optimal technique and knowledgeable pattern recognition of diseases are the pre requisites to use the potential of the modality to its full advantage. The present study is an endeavor in DPLDs in our hospital set up to evaluate the exact role of HRCT in forming a definitive diagnosis, predicting disease reversibility, to correlate the spectrum of findings with the functional impairment and evaluate the presence of superimposed complications.

METHODS

This cross sectional study comprised of sixty patients clinically suspected with diagnosis of diffuse parenchymal lung disease (DPLD) and referred for thoracic CT .The study was carried out at Department of Radio-Diagnosis, JLN Medical College and associated group of Hospitals, Ajmer (Rajasthan).The age of subjects varies from 6-88 years with mean age of 45 years. There was a female preponderance in the study (60%). Dyspnea was graded depending on the severity.

Patients were evaluated by CT scan in department of Radio-diagnosis from October 2014 to October 2016. All the patients of either sex , clinically suspected and radiographically diagnosed of DLPD underwent CT (MX-16 Philips, 3rd generation CT scan, matrix size 640x640, slice thickness : 0.5 mm to 1 mm). Pregnant women and diagnosed cases of tuberculosis (sputum positive) were excluded from the study.

RESULTS

The most common diffuse parenchymal lung disease encountered in our study group is idiopathic interstitial pneumonia accounting for 26.7% of cases (14 patients showing usual interstitial pneumonia (UIP) pattern and 2 patients with non UIP pattern). Tuberculosis formed the second major group constituting 14 cases. Miliary tuberculosis accounted for 28% of these cases and rest were other forms of active tuberculosis or sequelae of old disease. Six cases of bronchectasis accounting for 10% of cases were also seen (Table 1).

Dyspnea was the main presenting complaint in 75% of our study group. Out of these 75% had grade II or III dyspnea whereas 18% showed grade IV dyspnea at the time of presentation. The mean duration of dyspnea in subjects included in the present study was around 11 months ranging from 10 days to 3 years. Dyspnea was usually associated with cough at presentation.

Table 1: Distribution of cases (n=60)

Parenchymal Lung Diseases	No. of patients	%
Idiopathic interstitial pneumonia	16	26.7
Tuberculosis and post-tubercular disease	10	16.7
Bronchiectasis	6	10
Connective tissue disorders (including progressive systemic sclerosis and other diseases)	5	8.33
Hypersensitivity pneumonitis	4	6.7
Miliary tuberculosis	4	6.7
Sarcoidosis	3	5
Allergic bronchopulmonary aspergillosis	3	5
Silicosis	3	5
Radiation induced fibrosis	1	1.66
Diffuse metastases	1	1.66
Organizing pneumonia	1	1.66
Histiocytosis X	1	1.66
Lymphangioleiomyomatosis	1	1.66
Acute interstitial pneumonia	1	1.66

Clinical symptomatology is given in table 2. A history of occupational exposure was found in five patients. Three patients with silicosis had a long-term history of exposure to silica dust (10-12 years).Two Patients with hypersensitivity pneumonitis had a history of exposure to poultry. HRCT findings in idiopathic interstitial pneumonia are given in table 3, image 1.

Table 2: Percentage of clinical symptoms in patients

Clinical Symptoms	No of Patients (n=60)	Percentage
Dyspnea	45	75
Cough – dry	23	38.33
With expectoration	16	26.7
Fever	20	33.3
Chest pain	12	20
Malaise	29	48.3
Joint pains	5	8.3
Occupational exposure	5	8.3
History of smoking	14	23.3

In other forms of pulmonary tuberculosis, random or diffuse involvement of the lung by pulmonary tuberculosis and its sequelae were observed in 10 patients. A previous history of tuberculosis was elicited in six patients. Honeycombing with bronchovascular distortion and fibrosis were identified in 60% of the cases. Pleural thickening or effusion was identified in six cases. Mediastinal lymphadenopathy was seen in seven patients, most commonly the right paratracheal group. Three of these showed evidence of calcification (Image 3).

Branching centrilobular opacities with bulbous ends suggestive of fluid filled bronchioles were identified in four patients (66.7%). Three cases (50%) shows alveolar opacities (Image 4).

Table 3: HRCT findings in patients with idiopathic interstitial pneumonia

HRCT Findings	No of Cases (n=16)	Percentage
Predominant Pattern -		
Reticular	13	81.25
Nodular	0	0
Reticulonodular	3	18.75
Predominant zones involved-		
Upper	1	6.25
Mid	3	18.75
Lower	6	37.5
Diffuse	9	56.25
Predominant distribution-		
Central	0	0
Peripheral	6	37.5
Diffuse/random	10	62.5
Honeycombing	14	87.5
Ground glass haze	13	81.25
Traction bronchiectasis	9	56.25
Conglomerate fibrosis	7	43.75
Pleural thickening	14	87.5
Cardiomegaly with prominent pulmonary artery	7	43.75
Mediastinal/Hilar lymphadenopathy	6	37.5

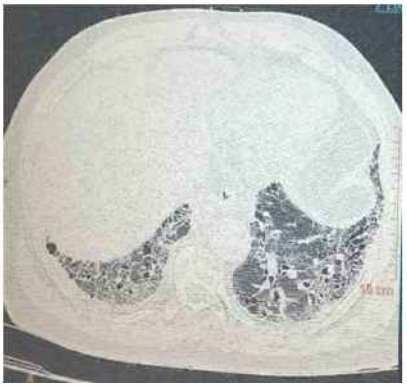
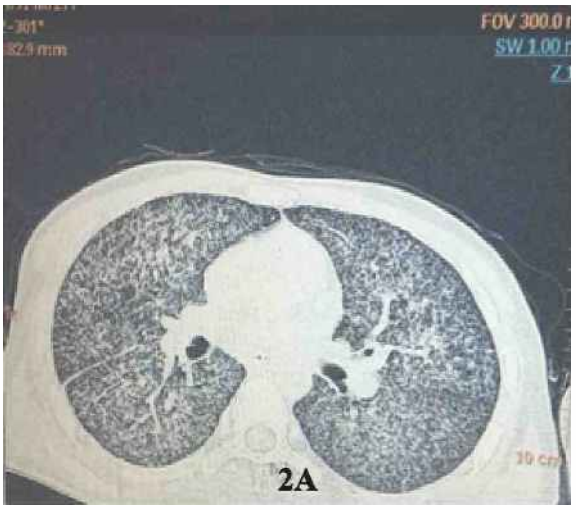


Image 1: Usual interstitial pneumonia.
(Lung window Axial View CT image shows reticular opacities with Honeycombing).



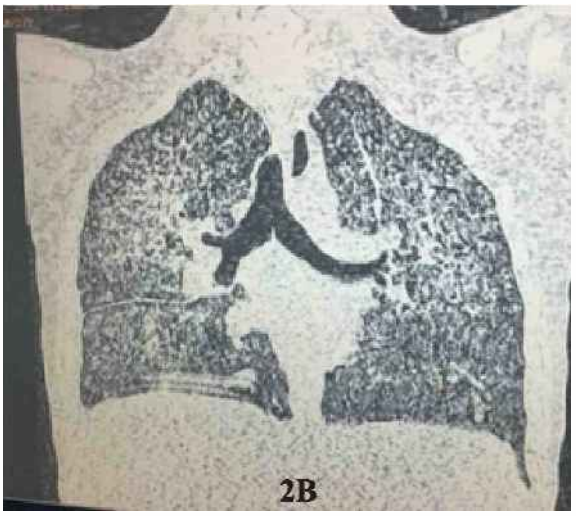
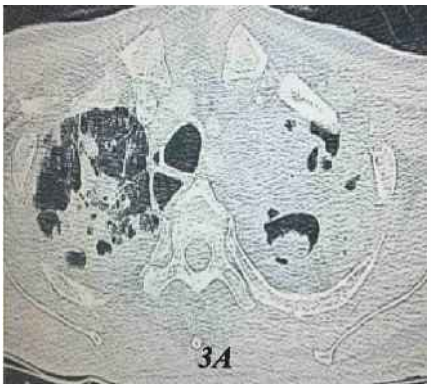


Image 2: Miliary Tuberculosis.
(2A and 2B: CT lung window Axial and Coronal view of similar patients shows diffusely scattered multiple small 1 to 3 mm nodular opacities with reticulonodular opacities noted in bilateral lung fields).



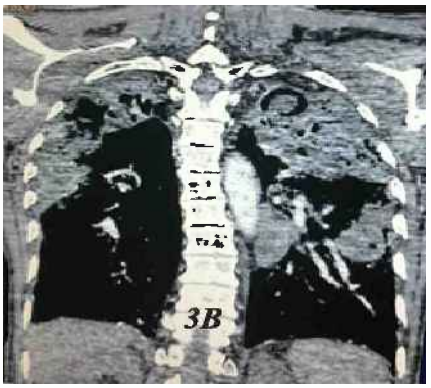


Image 3: Kochs sequalae with fungal infection.
(3A. Lung window Axial View of similar patient shows few fibrotic, fibronodular opacities, dense air space opacities with cavitation containing soft tissue density lesion and air crescent sign in left apicoposterior segment [Fungal Ball]).
(3B. Mediastinal window coronal view of similar patient shows few fibrocalcified opacities, dense air space opacities with cavitation containing soft tissue density lesion and air crescent sign in it [Fungal Ball]).

Table 4: HRCT findings in miliary tuberculosis and tubercular lung disease

Findings	Miliary Tuberculosis (n=4)	Percentage	Tubercular Lung Disease (n=10)	Percentage
Predominant zone-				
Upper	0	0	5	50
Mid	0	0	3	30
Lower	0	0	3	30
Diffuse	4	100	4	40
Predominant Pattern				
Reticular	0	0	3	30
Nodular	3	75	4	40
Reticulonodular	1	25	3	30
Honeycombing	0	0	3	30
Pleural thickening	0	0	6	60
Mediastinal/hilar lymphadenopathy	2	50	7	70
Cardiomegaly	0	0	3	30
Bronchiectasis	0	0	0	0
No significant abnormality	0	0	0	0
Alveolar Opacities	0	0	5	50
Ground Glass Haze	2	50	7	70

Patients with hypersensitivity pneumonitis comprised of 6.7% of the total cases. These patients were predominantly between 35-50 years of age and usually presented with low-grade dyspnea and fever. Two patients reported with a history of occupational exposure to poultry farm (Image 5).

DISCUSSION

The present study was undertaken to evaluate the radiological profile of diffuse parenchymal lung diseases using high-resolution computed tomography.

Dry cough was present in 38% of the patients. 26.7% patients had associated expectoration that was either mucoid, mucopurulent or hemoptysis. Purulent sputum was associated with the presence of bronchiectasis. Hemoptysis was present in six of the 10 patients (60%) with tubercular or post-tubercular DPLD. One case with a history of carcinoma lung presented with hemoptysis .

Acute onset chest pain and breathlessness secondary to pneumothorax was present in each case of histiocytosis X and lymphangioleiomyomatosis. A significant increase in the severity and duration of dyspnea was not found in these patients. Due to the preponderance of females in our study group and a male bias towards smoking in our society, the exact significance of smoking history could not be elicited (Table 2).

The age of patients with idiopathic interstitial pneumonia ranged from 37 to 88 years with most of the cases between 50-65 years. There was a preponderance of females in accordance to other studies .[4,5,6] On HRCT scans, the predominant features observed were interlobular and intralobular septal thickening (94% cases) in a reticular pattern throughout the lung fields. Thickening of the

interstitial network of the lung by fluid, fibrous tissue or cells primarily results in this appearance. Though a diffuse pattern of disease was observed in 56% of cases, the lower zones and the peripheral lung fields were more commonly involved. Honeycombing was present in 88% of cases, more commonly present in the subpleural and peripheral location. Honeycombing is pathologically defined by the presence of small air-containing cystic spaces, generally lined by bronchiolar epithelium, and having thickened walls composed of fibrous tissue.[7] Traction bronchiectasis and conglomerate fibrosis were associated with the presence of honeycombing (Table 3).

HRCT scans showed randomly distributed fine nodular lesions measuring 1 to 3 mm scattered throughout both lung fields in all the cases. The random distribution of the nodules is due to massive lymphohematogenous dissemination of tubercle bacilli. Mediastinal lymphadenopathy was predominantly seen in of the cases, predominantly the right paratracheal group of lymph nodes. In one case, multiple hypodense lesions were seen both in liver and spleen and another case in spleen suggestive of granulomas. Evidence of tuberculosis of D_{12} vertebra with associated paraspinal abscess was seen in another case.

The predominant findings on HRCT in all the patients with active tuberculosis (60% cases) included patchy air space consolidation of varying degrees (50% cases) ,

fibrotic opacities, poorly defined nodular opacities few of them showing cavitation (60% cases) and interlobular septal thickening (40% cases). The granulomas resolve to a fibrocalcific scar. By erosion into a bronchiole, drainage of the caseous focus transforms it into a cavity.[8] An ill-defined aggregation of centrilobular nodules suggestive of endobronchial spread was seen in four patients due to the implantation of tubercle bacilli on the mucosal lining of the air passages (Image 3).

Most patients with bronchiectasis presented with purulent sputum production and recurrent pulmonary infections. On HRCT, the bronchial dilatation was identified when the internal diameter of the bronchus was greater than that of a neighbouring pulmonary artery branch.[9] Taking these criteria, bronchiectasis were seen in all the cases thus having a sensitivity of 100%. Other findings included thickening of the bronchial wall and lack of bronchial tapering in the peripheral lung field in cylindrical bronchiectasis.

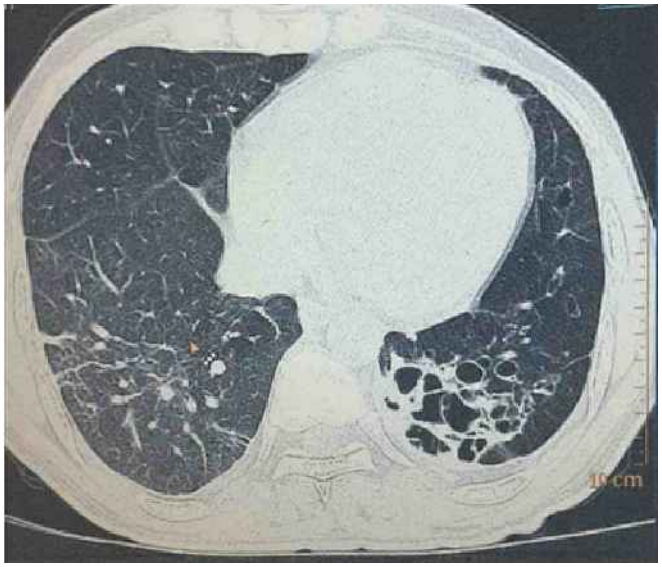


Image 4: Case of Bronchiectesis.

(Lung window CT Axial View at lower lobe level image shows cystic and tubular bronchiectesis with mucus plugging is noted).

On HRCT, diffuse ground glass haze was present in all the patients in our study. A previous study has reported ill defined centrilobular nodules in 75% of cases and most common abnormality was the presence of ground glass haze seen in 73% of patients with poorly defined nodules measuring upto 4mm in diameter seen in 40% cases.[10] Honeycombing with associated traction bronchiectasis and fibrosis were seen in one case of chronic hypersensitivity pneumonitis with progressive fibrosis (Image 5).

The present study included five patients with connective tissue disorders. Two of these were diagnosed cases of progressive systemic sclerosis (PSS) by skin biopsy (Image 6). One patient was a known case of mixed connective tissue disease. All the patients were females in the age group of 24 to 48 years. Patients usually presented with low-grade dyspnea and joint pains. Two cases of PSS had skin involvement with the presence of nodules. On CT, a typical pattern of peripherally distributed (80%) reticular opacities (80%) with lower zone predominance was seen in four out of the five cases. These reflect the occurrence of chronic interstitial fibrosis in these patients. Honeycombing was present in 60% cases mostly in a subpleural location. Ground glass haze was present in all the cases.[11] In two cases (40%) with progressive systemic sclerosis, evidence of esophageal dilatation was seen in the mediastinal window scans. Enlarged mediastinal nodes were seen in 60% of the cases. Cardiomegaly with a prominent pulmonary artery was seen in three cases (60%) of connective tissue disorder. HRCT images show enlargement of the pulmonary arteries and bilateral diffuse mosaic patterns of lung attenuation. A wide spectrum of radiological findings are described in Rheumatoid arthritis, reticular opacities (with or without honeycombing), air way associated abnormality such as bronchiectasis and wall thickening, parenchymal nodule and pleural effusion. Ground glass opacity (GGO) and reticular lines seen in bibasilar distribution (rheumatoid lung).[12] Honeycomb cysts may be seen in late stages of the disease with a predilection for the peripheral lung bases. Chronic damage to the small airways may occur rarely with scarring and loss (constrictive or obliterative bronchiolitis).[5,13]

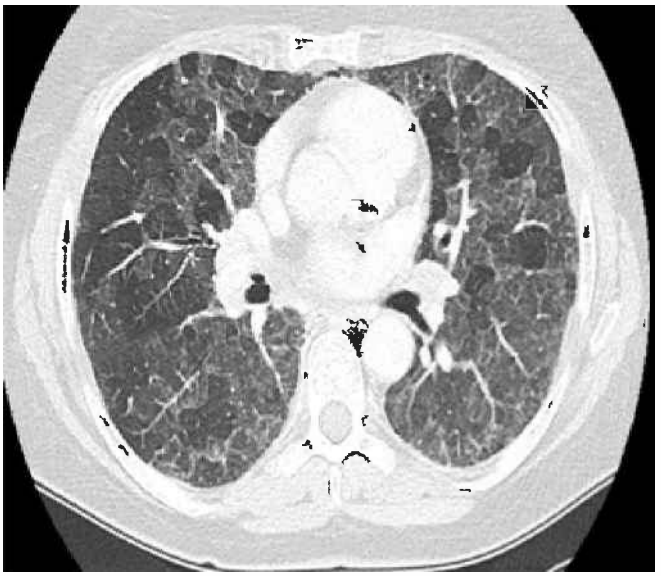


Image 5: Hypersensitivity pneumonitis

(Lung window Axial View images of similar patient shows diffuse bilaterally symmetrical ground glass opacity, areas of low attenuation mosaic pattern, septal thickening, nodules, reticular opacities).

Patients with sarcoidosis comprised of 5% of cases in our study. Symptoms of pulmonary sarcoidosis included progressive dyspnea usually grade II and constitutional symptoms such as fever, malaise and joint pains. On HRCT, a nodular pattern of interstitial thickening was the predominant finding present in 66% of cases. A predominant central distribution of the nodules was seen in 66.7% cases with more common involvement of the upper and mid zones of the lungs (Image7). A perilymphatic distribution of nodules along the peribronchovascular (66.7%), centrilobular (66.7%) and the subpleural interstitium was found in majority of the cases. These perilymphatic nodules are due to the presence of non-caseating granulomas.[13] Conglomerate nodules measuring more than 1 cm in diameter was present in one case . Honeycombing was seen in 66% of cases, more commonly in the upper and mid zones in a subpleural location. These cases represent advanced disease with progressive fibrosis. Mediastinal and hilar lymphadenopathy was apparent on CT in 100% of the cases of sarcoidosis. The predominant groups involved were right paratracheal (l00%) right hilar (66.7%), subcarinal and precarinal regions. Large anterior mediastinal nodes were also seen in one of the cases.

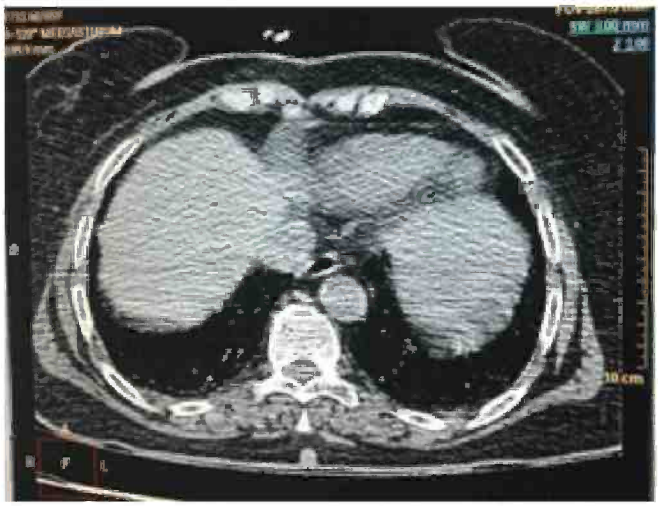


Image 6: Progressive Systemic Sclerosis.

(Mediastinal window Axial View of similar patient at above the diaphragm shows dilatation of lower esophagus).

Three cases of Allergic Bronchopulmonary Aspergillosis (ABPA) were included in our study. Two cases presented with fever and respiratory distress with wheezing. Bronchiectasis involving predominantly the central bronchi was seen in two patients (66.7%) on HRCT scans. Alveolar opacities were seen in all the three cases. Air space consolidation with an air-bronchogram was seen in the left lower lobe of lung in one case. Ill-defined centrilobular branching opacities suggestive of a tree-in-bud pattern were seen in one case. This finding is due to the dilatation of mucus filled centrilobular bronchioles.[14]

Three patients of silicosis with a history of exposure to silica dust for 10-12 years presented with grade II and III dyspnea. On CT, nodular opacities along the peribronchovascular, centrilobular, interlobular and subpleural regions were identified predominantly in the upper and mid zones. Conglomerate fibrosis (66.7%) with honeycombing (33%) was also identified.[15] These findings reflect the presence of peribronchiolar nodules consisting of layers of connective tissue (Image 8). Bilateral hilar and mediastinal lymphadenopathy was also present in one case (33%).

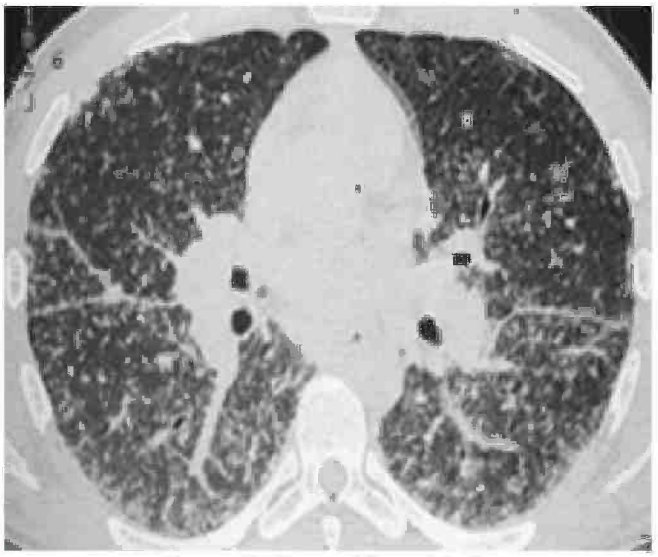


Image 7: Case of Sarcoidosis

(Lung window Axial View shows multiple small randomly distributed predominantly perilymphatic nodules with bronchovascular interstitial thickening).

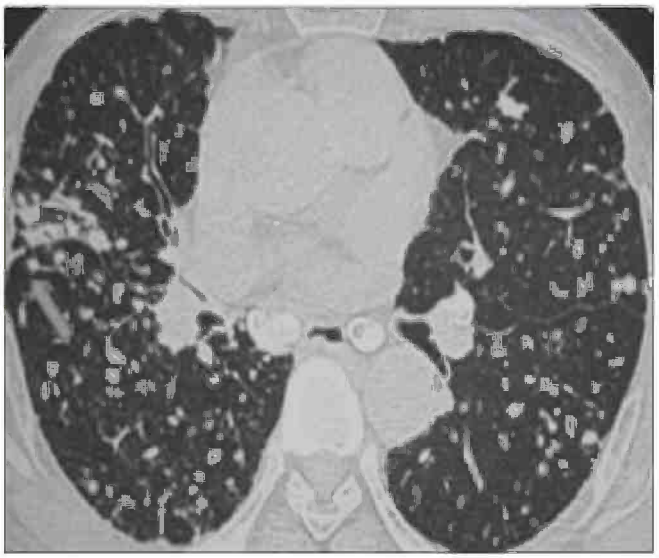


Image 8: Case of Silicosis

(Lung window Axial View of silicosis patient shows small well-defined nodules in bilateral upper lobes).

Diffuse lung metastases were seen as multiple large, well-defined nodules spread in both lung fields in the chest radiograph of a fifty nine year old female patient with a known history of malignancy (breast carcinoma). On CT, the discrete nodules had a uniform distribution throughout the lung with no specific relationship to lobular structures and interlobular septa.

An eight year old male patient presented with complaints or acute exacerbation of progressive dyspnea and low-grade fever. HRCT scans revealed multiple, both thin and thick walled cystic spaces, some confluent or with bizarre shapes in both lung fields with relative sparing of the bases. Small nodules in a peribronchovascular and centrilobular distribution were also seen throughout both lung fields. These nodules are peribronchial granulomatous aggregations of Langerhans histiocytes and eosinophils[16]. A loculated pneumothorax was present in the right upper chest anteriorly with partial collapse of the underlying lung. Spontaneous pneumothorax can be present in upto 10-15% of the cases of Histiocytes X (HX) at presentation. Mediastinal lymphadenopathy was also present in this patient.The lung volumes were relatively preserved in this patient, a finding helpful in differentiating HX from other diffuse lung diseases.

A 36 year old female patient presented with a history of recurrent pneumothoraces and an acute onset dyspnea.The HRCT scans of this patient showed the presence of numerous irregularly shaped thin walled cystic lucencies of varying sizes seen diffusely throughout both lung fields.These cysts occur due to proliferation of spindle cells along the bronchioles leading to air trapping and development of emphysema and thin-walled cysts. The parenchyma in between the cysts showed evidence of reticular interlobular and intralobular septal thickening and ground glass haze.[17]A pneumothorax was present in the right chest cavity with partial collapse of the right upper lobe. Pneumothorax occurs in 30 to 40% of cases of lymphangioleionnyomatosis.

A 64 year-old known case of bronchogenic carcinoma of the right lung was on regular radiotherapy and presented with progressive dyspnea and cough. The HRCT scans of this patient showed the presence of dense consolidation due to conglomerate fibrosis (scarring) in the left lung with evidence of volume loss and hyperinflated right lung field .[18] One case of organizing pneumonia was identified in our study with history of low-grade fever, malaise and shortness of breath for three months. HRCT scans of patient showed the typical pattern of patchy areas of air-space consolidation in a peripheral subpleural distribution in both lung fields. The pathological basis of these findings is the presence of granulation polyps within the lumina of bronchioles and alveolar ducts and patchy organizing pneumonia. Mediastinal lymphadenopathy was also present.A six year old patient presented with acute onset fever and severe respiratory distress. CT scans of the chest revealed multiple geographic areas of ground glass attenuation in both lung fields with bilateral hilar and mediastinal lymphadenopathy.[19] The pathologic abnormalities consisted of thickening of the alveolar walls due to edema and inflammatory cells suggestive of acute interstitial pneumonia.

Idiopathic interstitial pneumonia forms the major group of diffuse parenchymal lung diseases in our society. Bibasilar inspiratory crackles are the most common finding on physical examination. The clinical findings are however, non-specific for the various diseases. A thorough radiological examination involving high resolution computed tomography of the chest is required for reaching an accurate diagnosis.[20,21]

CONCLUSION

Diffuse parenchymal lung diseases commonly occur in the middle age, the presenting complaint being unremitting dyspnea of long duration in most cases. Certain HRCT features are diagnostic for individual diseases in a proper clinical setting like interlobular, septal thickening and peripheral honeycombing in UIP, diffuse ground glass haze for hypersensitivity pneumonitis and cystic lesions in histiocytosis X and lymphangioleoiomyomatosis. The extent and distribution of disease identified on HRCT scans correlates well with the clinical impairment.

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