CHEST RADIOGRAPH AND HRCT IN CHRONIC LUNG DISEASE

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ABSTRACT

BACKGROUND

HRCT uses high spatial resolution of lung parenchyma, using thin collimation, high-spatial frequency reconstruction algorithm and increased kVp and mA settings. Alterations in anatomy can be identified at level of secondary pulmonary lobule, which can be diagnostic, although nonspecific.

MATERIALS AND METHODS

50 patients underwent HRCT and chest radiograph in our hospital in this retrospective study after fitting into clinical criteria. Patient underwent chest x-ray and CT scan with an interval of half an hour to one hour and both findings were correlated based on previous studies.

RESULTS

We had 50 patients with child to older age group patients of both sex. Patients were categorised depending on normal and abnormal x-ray chest, HRCT and depending upon density of ground-glass opacity.

CONCLUSION

HRCT takes over routine chest radiography in diagnosis of chronic lung disease. HRCT helps in excellent diagnosis and prognosis of disease. HRCT helps in localising site for tissue sampling. Thus, HRCT is an excellent imaging modality for chronic lung disease.

KEYWORDS

HRCT, GGO, Fibrosis.

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BACKGROUND

"Chronic lung disease is arbitrarily defined as lasting for more than 2 weeks or 1 month."[1] Although, chest radiography is useful and inexpensive method for examining patients who have diffuse lung disease, it has well-known limitations. Findings on the radiograph are often normal in symptomatic patients with pathologically-proved diffuse lung disease, they seldom allow a confident diagnosis and they correlate poorly with clinical and functional impairment. Approximately, 10% of patients who eventually prove to have infiltrative lung disease have a normal plain radiograph at presentation.[2,3] Mathieson[4] reported considerable superiority for HRCT over chest radiography. HRCT can show abnormalities in patients who have normal findings and because it provides accurate assessment of pattern and distribution of lung disease. It allows confident diagnoses in patients who have normal or nonspecific findings in conventional radiography. HRCT techniques are capable of imaging lung with excellent spatial resolution providing anatomic detail similar to that available from gross pathologic specimens or lung slices. HRCT can demonstrate the normal to abnormal lung interstitium and morphologic characteristics of both localised and diffuse parenchymal abnormalities and hence superior to plain radiographs and conventional CT.

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Aims and Objectives

The aim of our present study is to summarise clinical usefulness of HRCT in patients with chronic lung disease, and suggest specific indications based on a review of literature. The clinical value of HRCT is assessed in terms of its ability to detect diffuse chronic lung disease, confirm or refute presence of abnormality when chest radiograph is normal; and its ability to determine the optimal type and site of lung biopsy.

MATERIALS AND METHODS

A retrospective study was conducted on 50 patients underwent HRCT without contrast and chest radiograph in our hospital. All patients who fulfilled the following clinical criteria were taken into consideration. (1) Progressive increase in shortness of breath on exertion or at rest not responding to treatment more than 2 weeks to one month. (2) Paroxysmal nonproductive cough of long duration. (3) Fine dry end-inspiratory crackles posteriorly at lower chest. (4) Positive occupational history. (5) Abnormal chest radiograph. (6) Abnormal pulmonary function tests. Chest

radiograph and CT scan were performed on the same day for each patient. All scans were obtained using siemens somatom emotion 16-slice CT scanner. The following HRCT protocols were used- Scan orientation -craniocaudal, patient position- supine (prone scans for ILD Technique- patient position- prone early fibrosis, Expiratory- obstructive lung diseases, scan spacing- 1 cm intervals, 3 or 4 cm intervals, limited HRCT- 3 preselected, levels (aortic arch, carina, 2 cm above right hemidiaphragm, gantry angulation- 20 degrees caudally in bronchiectasis)), collimation- 1.5 mm, scan time- 1 sec, 120 kvp, 150 mA, 512 x 512 matrix, wl- 600, ww- 1500, no contrast, bone reconstruction algorithm, spacing at 5 preselected levels- (apices, aortic arch, hilar, infrahilar, 1 cm above right dome of diaphragm), full inspiration (expiratory scan done in cases where small airway disease was suspected. Technique CT or HRCT obtained during forced exhalation (dynamic expiratory CT) during suspended respiration after forced exhalation (postexpiratory CT) or at a user-selected respiratory level controlled during exhalation using a spirometer (spirometrically-triggered expiratory CT). The CT scans were analysed for type, size and extent of small opacities, presence or absence of reticular pattern, reticulonodular shadowing, ground-glass shadowing, mosaic perfusion, traction bronchiectasis, honeycomb cysts and septal lines. The distribution of abnormalities were classified as being either predominantly upper or lower zone as being central, diffuse, posterior or peripheral as having either predominantly peribronchovascular or subpleural or distribution or as being randomly distributed. These findings were then interpreted on the basis of previously published data on radiographic and HRCT findings.

RESULTS

Our study comprised of 50 patients (54% males, 46% females) with age range from 10-80 years (mean age- 45.42 years).

Total no. of patients with normal chest radiography	8	16%
Total no. of patients with abnormal chest radiography	42	84%
Total no. of patients with normal CXR and abnormal HRCT	8	16%
Total no. of patients with abnormal CXR and abnormal HRCT	42	84%
Total no. of patients abnormal CXR and normal HRCT	Nil	Nil

Table 1. Chest Radiograph Vs. HRCT

Eight cases, which appeared normal on chest radiographs were detected as abnormal on HRCT, whereas all cases abnormal on chest radiograph were also abnormal on HRCT.

Disease	Number of Patients	Percentage
Idiopathic pulmonary fibrosis	9	18%
Pulmonary tuberculosis	20	40%
Pneumocystis carinii pneumonia	3	6%
Alveolar microlithiasis	4	8%
End-stage lung disease	1	2%
Histiocytosis X	1	2%
BOOP	2	4%
Lung metastases	3	6%
Lymphangitis carcinomatosa	2	4%
Diffuse alveolitis	1	2%
ARDS	1	2%
Rheumatoid arthritis	2	4%
Sarcoidosis	1	2%
Total	**50**	

Table 2. Disease Incidence

Tuberculosis followed by idiopathic pulmonary fibrosis were most common diseases in our study. Isolated cases of end-stage lung disease, histiocytosis X, sarcoidosis, rheumatoid arthritis and diffuse alveolitis were also identified. One case of familial alveolar microlithiasis was also present. Three cases of pneumocystis carinii pneumonia in immunocompromised patients were also identified.

Disease / Character	PTB N=20	IPF N=9	HIV/PCP N=3	ALVEOLAR MICROLIT-HIASIS N=4	ESLD N=1	HISTIO-CYTOSIS N=1	BOOP N=2	LUNG METASTASES N=3	LYMPHANGITIS CARCINOMATOSA N=2	DIFFUSE ALVEOLITIS N=1	ARDS N=1	SARCO-IDOSIS N=1	RHEUMATOID ARTHRITIS N=2
Sex Male	14 (70%)	6 (66.6%)	0	1	1	1	2 (10 %)	-	1 (50%)	1	-	-	-
Female	6 (30%)	3 (33.3%)	3 (100%)	3	-	-	-	3 (100%)	1 (50%)	-	1	1	2
Median age	46 Yrs.	48 Yrs.	37 Yrs.	27 Yrs.	70 Yrs.	55 Yrs.	45 Yrs.	48 Yrs.	67 Yrs.	48 Yrs.	35 Yrs.	35 Yrs.	57 Yrs.
Nonsmoker	9 (30%)	7 (77.7%)	3 (10 0%)	4 (100%)	-	-	-	3 (100%)	1 (50%)	-	1	1	2
Smoker	14 (70%)	2 (22.2%)	0	-	1	1	2 (10 0%)	-	1 (50%)	1	-	-	-
No smoking data	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 3. Demographic Data

Prevalence of pulmonary tuberculosis was high in male smoker with mean age of 46 yrs. Prevalence of idiopathic pulmonary fibrosis was high in male non-smokers with mean age of 48 yrs. Alveolar microlithiasis was found to affect younger age groups and was slightly common in females. End-stage lung disease and lymphangitis carcinomatosa tend to affect older age groups.

Feature / Case	Intensity of GGO Range (1-3)	Extent of GGO Range (1-4)	Extent of Fibrosis Range (1-4)	Coarseness of Fibrosis (0-15)	Traction Bronchiectasis Range (0-10)	Severity of GGO Range (2-7)	Severity of GGO
Case 1	2.4	2	2	8	4	4.4	Moderate-to-severe
Case 2	2	3.2	1	2	0	5.2	Moderate-to-severe
Case 3	2	1	2	10	7	3	Mild
Case 4	2	1.4	1	5	0	3.4	Mild
Case 5	2.2	3.2	1.6	5	4	5.4	Moderate-to-severe
Case 6	2.4	2	2	8	4	4.4	Moderate-to-severe
Case 7	2	2	2	9	4	4	Mild
Case 8	1	2	1	5	0	3	Mild
Case 9	1	1	2	10	7	2	Mild

Table 4. Quantification of Ground-Glass Opacification and Fibrosis in IPF

Intensity	Number of Patients
Low	2 (22%)
Moderate	4 (45%)
Severe	3 (33%)

Table 4a. Intensity of GGO

Extent	Percentage
<25%	2 (22%)
25-50%	5 (55.6%)
50-75%	2 (22%)
>75%	-

Table 4b. Extent of Ground-Glass Opacification

GGO Severity	Present Study	Remy Jardin et al
Mild	5 (55.6%)	46%
Moderate-to-severe	4 (44.4)	54%

Table 4c. Severity of Ground-Glass Opacification

Grade	Percentage
I	55%
II	44%
III	1%

Table 4d. Grading of Opacification

Feature	Active (n=11)	Inactive (n=9)	Overall
Tree-in-bud opacity	10 (90.9%)	8 (88%)	90%
Centrilobular nodules	8 (72%)	6 (66.7%)	70%
Ill-defined nodules	5 (45.5%)	5 (55.5%)	50%
Cavitation	7 (63.6%)	6 (66.7%)	65%
Lobar consolidation	9 (82%)	3 (33.3%)	50%
Septal thickening	1 (9%)	3 (33.3%)	20%
Ground-glass opacity	8 (72.7%)	1 (11%)	45%
Linear scar	7 (63.6%)	7 (77.7%)	70%
Pleural thickening	3 (27.3%)	7 (77.7%)	50%
Adenopathy	1 (9%)	-	5%
Total	**11 (55%)**	**9 (45%)**	**100%**

Table 5. Findings in Sputum-Positive and Sputum-Negative Tuberculosis

Total no. of cases = 20.
Total no. of sputum (+) cases = 11 (55%).
Total no. of sputum (-) cases = 9 (45%).

Prevalence of ground-glass opacity, lobar consolidation, tree-in-bud opacities, centrilobular nodules was more in active tuberculosis compared to inactive tuberculosis. Similarly, prevalence of linear scar, interlobular irregular septal thickening and pleural thickening was higher in patients with inactive tuberculosis.

Feature	Feature Number of Patients	Percent
Bilaterality	3	100%
Diffuse involvement	3	100%
Nodules	1	33.3%
Consolidation	2	66.6%
Ground-glass opacity	3	100%
Thin-walled cysts	1	33.3%
Pleural thickening		-
Adenopathy		
Pneumothorax		-

Table 6. Summary of Findings in HIV (+) Patients with Pneumocystis Carinii Pneumonia Infection

Total number of HIV (+) patients = 3.
Total number of patients with abnormal radiographs = 2 (66.6%).
Total number of patients with normal radiographs = 1 (33.3%).
Total number of patients with positive HRCT findings = 3 (100%).

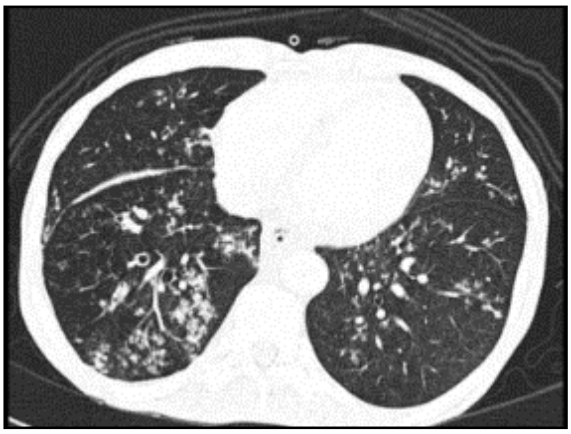

Figure 1. Tree-in-Bud Opacities

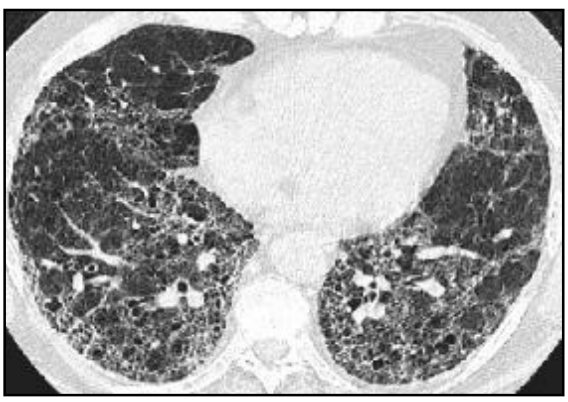

Figure 2. ILD

DISCUSSION

Only very few studies regarding diagnostic accuracy of chest radiograph and CT have been published. Matheison et al[4] reported that in 118 patients with chronic diffuse infiltrative lung disease, interobserver variation was minimal and interobserver agreement was more accurate using HRCT than interpretation using chest radiograph. They subsequently recommended that CT scanning should precede lung biopsy in all patients. Similarly, in other three studies, utilising 48 selected patients with chronic DILD (Bergin et al), 140 consecutive patients with chronic DILD (Grenier et al), and 86 patients with chronic DILD mixed with normal subjects (Padley et al).[5] HRCT was determined to be superior to conventional radiograph in the diagnosis of chronic DILD.

HRCT versus Chest Radiograph

(Table 1)- Felson[6] showed that prediction of microscopic distribution from plain radiograph pattern is unreliable. Even when chest radiograph shows definite evidence of diffuse lung disease McCloud has pointed that "the chest radiograph is often nonspecific and rarely diagnostic." This is due to the fact that there is super imposition of structures on lungs leading to observation, which is further compounded by presence of pleural thickening. In our study, plain radiography was normal in 8 (16%) of patients. Epler and Gaenslen and Carrington concluded that approximately 10% of patients who eventually prove to have interstitial lung disease have a normal plain radiograph at presentation. In our study, HRCT was abnormal in all 8 patients who had a normal chest radiograph. In no case was HRCT felt to be normal when the chest radiograph was described as abnormal. Padley reported that out of 18 chest radiographs erroneously called normal, 11 were described as abnormal on HRCT (62%). They also reported that in no case was HRCT felt to be normal when the chest radiograph was described as normal. Thus, in our study, the role of HRCT in face of equivocal chest radiograph has been confirmed. Matheison concluded that correct diagnosis was made in 77% of chest radiography and 93% of CT scan reading ($p<0.001$).

Quantification of Ground-Glass Opacification

(Tables 4, 4-A, B, C)- Out of 9 cases of IPF diagnosed in our study, 22%, 45% and 33% had low, moderate-to-severe GGO intensity scores, respectively. The extent of GGO involvement was 75% involvement in 40% of cases. Remy Jardin et al[7] evaluated the importance of scoring of ground-glass opacification and fibrosis in chronic diffuse infiltrative lung disease. A mild ground-glass opacification was defined as GGO score >4. In our study, 55.6% had mild GGO severity score and 44.4% had moderate-to-severe GGO severity score. These results are comparable to the above study by Remy Jardin et al who showed that 46% had mild GGO and 54% had moderate-to-severe GGO.

Quantification of Fibrosis- In our study, 75% of cases with IPF who had severe GGO scores also had a severe overall coarseness of fibrosis score. The prevalence of traction bronchiectasis was also high in these patients (75%). Remy Jardin et al[7] observed a trend towards onset or increase in honeycombing and traction bronchiectasis in patients with most severe GGO profusion score at initial CT evaluation. According to Westcott et al in patients with IPF, the presence of bronchiectasis does not necessarily imply the presence of primary bronchial disease. In general, there was a direct relationship between the severity of fibrosis and presence and severity of bronchiectasis. In our study, there was a direct relationship between the coarseness of fibrosis scores and traction bronchiectasis. The extent of traction bronchiectasis was higher in patients who had a severe coarseness of fibrosis score and high GGO severity score. Patients with low GGO intensity, extent scores had also low GGO severity scores, low coarseness of fibrosis scores.

HRCT and IPF- (Table IVD)

HRCT was found to be more sensitive in detecting disease activity and prognosis in patients with idiopathic pulmonary fibrosis. In our study, out of 9 cases of IPF, 55% had grade I parenchymal opacification, 44% had grade II parenchymal opacification and 1% had grade III parenchymal opacification. Bilateral lower zone involvement was present in virtually all patients (100%). In a study by Leung et al,[8] out of 15 patients with IPF, 8 patients had grade I opacification (53%), 6 patients had grade II opacification (40%) and only one had grade III opacification (6.6%). Grade II and grade III disease indicated high grade. Bilateral involvement was present in 8 out 15 patients (54%). Lower

zone involvement occurred in 10 patients (77%). Most common pattern of involvement was bilateral and diffuse present in all patients. In our study, out of 9 patients with idiopathic pulmonary fibrosis who had predominantly GGO showed mild-to-moderate symptomatic improvement on treatment with steroids and patients who had predominantly fibrosis and traction bronchiectasis showed little response to treatment. Wells et al[9] divided CT findings in IPF into three groups- Group I - Predominantly GGO; Group II - Mixed GGO and reticular opacities; Group III - Predominantly reticular opacities. Response to therapy was significantly greater in patients who had predominantly GGO and greater in group II than group III. Ground-glass opacification indicated reversible and potentially treatable disease, whereas fibrosis and traction bronchiectasis indicate irreversible disease. Definitive diagnosis is involvement of bilateral lower zones and ground-glass opacity.

HRCT and Pulmonary Tuberculosis

(Table 5)- In our study, 20 cases of pulmonary tuberculosis were identified. Out of these, tree-in-bud opacities were present in 90%, centrilobular nodules in 70%, poorly-defined nodules 50% and cavitation 65%. Tree-in-bud pattern was most common pattern observed. Im et al[10] showed the high frequency of HRCT finding of endobronchial spread of infection in post-primary tuberculosis. In post primary tuberculosis, tree-in-bud opacities were seen in 92%; centrilobular nodules in 67%; bronchial wall thickening in 50-73%; poorly-defined nodules in 42%; and cavitation in 58%. With this, they concluded that tree-in-bud opacities were most common and earliest manifestation of bronchogenic dissemination. In our study, 11 cases were sputum positive and 9 cases were sputum negative. Prevalence of various findings in active tuberculosis were ground-glass opacification-72%, tree-in-bud 90.9%, lobar consolidation-82%, centrilobular nodules-72.7%, interlobular septal thickening-9% and linear scar-63%. Prevalence of various findings in inactive tuberculosis were ground-glass opacification-11%, tree-in-bud opacities-88%, lobar consoliation-33.3%, centrilobular nodules-66.7%, interlobular septal thickening-33% and linear scar-77%. Hatipoglu and co-workers 11 compared HRCT findings in 32 patients who had active and inactive pulmonary tuberculosis. Tree-in-bud opacities (71%), nodules (69%), consolidation (44%) and centrilobular opacities (91%) were identified in patients with active disease. They concluded that centrilobular opacities, tree-in-bud opacities are the most useful findings to differentiate active from inactive disease. The prevalence of linear scar and irregular interlobular septal thickening was higher in patients with inactive tuberculosis. Definitive diagnosis is of centrilobular and tree-in-bud opacities.

Role of HRCT in AIDS Patients

(Table 6)- In our study, HRCT detected intrathoracic disease in 100% of patients who were HIV positive. These results are comparable to study by Hartmann, which showed that HRCT-detected intrathoracic disease in 99% of patients who were HIV positive. In our study, three HIV positive patients in whom persistent hypoxaemia was present in 2 cases had pneumocystis carinii pneumonia infection. Plain radiographs were abnormal in 2 cases (66%) and revealed diffuse hazy opacification of lung parenchyma bilaterally. HRCT was abnormal in above all cases (100% sensitivity). Diffuse bilateral involvement was most common pattern involved seen in 100% of cases. The most common finding was ground-glass opacification seen in all patients followed by diffuse patchy consolidation (66%). Thin-walled cysts were seen in 1 patient (33%). Hartman studied 24 patients who had pneumocystis carinii pneumonia infection. CT findings included GGO in 92%, consolidation in 38%, cystic change in 33%, pleural effusion in 17% and lymphadenopathy in 25%. Kang et al[15] reported a sensitivity of 90% for chest radiography and 96% for CT in detecting intrathoracic complications of AIDS. In our study, HRCT effectively detected GGO in all three AIDS patients indicating presence of pneumocystis carinii pneumonia infection and this finding correlated well with hypoxaemic status of the individual. Hartman stated that the finding of GGO on HRCT in patients with AIDS, particularly those with hypoxaemia is virtually diagnostic of pneumocystis carinii pneumonia infection. Grueden documented that especially in AIDS patients who have equivocal radiographs. HRCT plays an important role by excluding presence of GGO, thus excluding presence of pneumocystis carinii infection (100% sensitivity, 89% specificity). In AIDS patients who have suspected pneumocystis carinii pneumonia infection and normal or equivocal chest radiograph, sensitivity of HRCT has been shown to be 100% in making diagnosis, whereas specificity was shown to be 89%.[13] In our study, the sensitivity of HRCT in detecting pneumocystis carinii pneumonia in AIDS patients was 100%. Definitive diagnosis of pneumocystis carinii pneumonia in AIDS patients is with ground-glass opacity particularly with hypoxaemia.

Isolated Cases- In our study, only one case of histiocytosis X with grade I parenchymal opacification was identified. Thin-walled cystic changes was present in both lung fields predominantly located in upper and mid zones. Right pneumothorax was also present. Moore showed that cystic changes and nodules were the predominant HRCT findings in histiocytosis X, usually thin-walled cysts are present. They showed that these patients were prone to pneumothorax. In our study, only one case (2%) of end-stage lung disease was identified. Gaensler and Carrington[3] identified a prevalence of 3.4% for end-stage lung disease in 502 patients indicating severe lung fibrosis. Few isolated cases of sarcoidosis, lymphangitis carcinomatosa, histiocytosis rheumatoid arthritis and BOOP were also detected in our study. Our study had two main limitations. First, it included a small number of cases. Second, in all patients, diagnosis was based on clinical radiography and HRCT findings rather than biopsy.

CONCLUSION

In conclusion, this study confirms superiority of HRCT over routine chest radiography for obtaining specific diagnosis in patients with chronic lung disease. We recommend clinical evaluation, conventional radiography and HRCT examination as integral part of appropriate initial evaluation of patients with chronic lung disease. In patients in whom CT does not provide diagnostic information, HRCT can help direct the surgeon to optimal site of biopsy (role of biopsy to provide a specific diagnosis, to assess disease activity, to exclude neoplastic and infectious processes, to identify a more treatable process than originally suspected, to make a definitive diagnosis and predict prognosis before proceeding with therapies). In patients with chronic lung disease, correlation of pathologic specimen with HRCT study gives best overall estimate of disease pattern and distribution.

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