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EVALUATING THE UTILITY OF CHEST HIGH RESOLUTION COMPUTED TOMOGRAPHY IN EARLY DETECTION OF FIBROSING INTERSTITIAL LUNG DISEASES

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Abstract

Background: *Interstitial lung diseases (ILDs) represent a diverse group of pulmonary disorders. High-resolution computed tomography (HRCT) is a cornerstone in their diagnosis and management.*

Objective: *This study aimed to evaluate the association between HRCT patterns and final diagnoses in patients with suspected ILD at a tertiary care center.*

Methods: *This cross-sectional study with a prospective component included 128 adult patients (17-85 years) with clinical suspicion of ILD undergoing HRCT at Arif Memorial Teaching Hospital, Lahore, over a 4-month period. Non-probability convenient sampling was used. HRCT scans were reviewed by experienced radiologists, and clinical data (demographics, symptoms, exposures) were collected. Associations between HRCT patterns (UIP, NSIP, HP, organizing pneumonia, DIP) and final diagnoses were analyzed. Short-term and long-term outcomes were also assessed.*

Results: *The mean age of participants was 47.9 ± 14.2 years, with a slight male predominance (54.7%). Common presenting symptoms included dyspnea (94.5%) and chronic cough (91.4%). Occupational dust was the most frequently reported exposure (18.8%). Strong associations were observed between specific HRCT patterns and diagnoses: UIP with IPF (77.8%), NSIP with NSIP (75.9%), HP with HP (70.5%), organizing pneumonia pattern with organizing pneumonia (75%), and DIP pattern with DIP (66.7%). Short-term outcomes showed symptom improvement in 81.0% and PFT stabilization in 79.5% of patients. Long-term follow-up revealed an 86.7% survival rate, with 18.0% experiencing disease progression and 23.4% requiring advanced therapies.*

Conclusion: *This study reinforces the crucial role of HRCT in suggesting specific ILD diagnoses based on characteristic patterns*

INTRODUCTION

Interstitial Lung Disease (ILD) encompasses a diverse group of pulmonary disorders characterized by varying degrees of inflammation and fibrosis[1]. Accurate diagnosis is essential for effective management. High-Resolution Computed Tomography (HRCT) has emerged as a cornerstone in ILD evaluation, offering detailed imaging of lung parenchyma. Fibrosing interstitial lung diseases (ILDs) are a group of chronic lung disorders characterized by scarring of lung tissue, leading to progressive breathing difficulties and a decline in quality of life[2]. These diseases arise from repeated injury to lung cells, resulting in excessive deposition of impairing gas exchange. ILDs encompass a diverse range of conditions, including idiopathic pulmonary fibrosis (IPF), connective tissue disease-associated ILDs, and hypersensitivity pneumonitis.

High-resolution computed tomography (HRCT) plays a crucial role in diagnosis, allowing for the visualization of early fibrotic changes such as ground-glass opacities, honeycombing, and reticular patterns, which are often missed by traditional chest X-rays[3]. HRCT helps distinguish between different ILD patterns, such as Usual Interstitial Pneumonia (UIP) and Nonspecific Interstitial Pneumonia (NSIP), which have different prognostic and therapeutic implications. UIP, often associated with IPF, is characterized by honeycombing and reticular opacities, while NSIP is typically associated with ground-glass opacities and a more uniform pattern of fibrosis[4-6].

Early diagnosis is crucial for optimal management, as it allows for timely initiation of treatment, such as anti-fibrotic medications (pirfenidone, nintedanib), immunosuppressive therapy, and pulmonary rehabilitation. Early intervention is particularly critical in diseases like IPF, where lung fibrosis can progress rapidly without treatment[7-10]. While ILDs are a significant health concern globally, their prevalence varies across populations. This emphasizes the growing importance of ILDs in Pakistan, particularly IPF[11]. The study aims to investigate the role of HRCT in the early detection of fibrosing ILDs within the Pakistani population to improve patient outcomes.

MATERIALS AND METHODS

This study is a cross-sectional study with a prospective component conducted at the Radiology Department of Arif Memorial Teaching Hospital, Lahore. The sample size was calculated to be 128 patients using a non-probability convenient sampling technique. Inclusion criteria included adults aged 18-80 years with clinical suspicion of ILDs, scheduled for HRCT of the chest, and who provided informed consent. Exclusion criteria included contraindications to HRCT, other primary lung diseases, inability to undergo HRCT due to other medical conditions, and pregnancy.

The study protocol was reviewed and approved by the Ethics Review Committee of Superior University, Lahore, and informed consent was obtained from all participants. HRCT scans were performed using standardized protocols, and images were reviewed by experienced radiologists. Clinical data was collected from medical records and patient performa.

Data analysis involved descriptive statistics and the analysis of HRCT images for specific patterns and abnormalities. Findings will be categorized and correlated with clinical and histopathological data. Sensitivity, specificity, positive predictive value, and negative predictive value of HRCT in detecting early fibrotic changes will be calculated using statistical software such as SPSS.

RESULTS

This study included 128 participants with suspected interstitial lung disease (ILD), providing a substantial dataset for analysis. The mean age of the participants was 47.9 years (SD = 14.2), indicating a relatively young cohort with a wide age range from 17 to 85 years. This broad age range suggests the inclusion of patients with various forms of ILD, which can manifest at different ages. The study population consisted of slightly more males (54.7%) than females (45.3%), reflecting the known slight male predominance in certain ILDs, although the

difference was not substantial. Regarding smoking status, a slight majority of participants (51.6%) had never smoked, while 12.5% were former smokers, and 35.9% were current smokers, as shown in **Table 1**. This distribution of smoking status is important to consider, as smoking is a well-established risk factor for some forms of ILD, particularly IPF and respiratory bronchiolitis-associated ILD.

The most common presenting symptoms were dyspnea (94.5%) and chronic cough (91.4%), highlighting the significant respiratory burden experienced by these patients. These symptoms are hallmarks of ILD and reflect the underlying inflammation and fibrosis parenchyma. Chest pain (69.5%) and fatigue (62.5%) were also frequently reported, indicating the systemic impact of these conditions. Weight loss, a symptom often associated with more advanced or progressive ILD, was reported by 32.0% of participants. Less frequent symptoms included fever (19.5%), which could suggest infection or certain inflammatory ILDs; malaise (12.5%); night sweats (7.0%), which can be associated with infections like tuberculosis or some malignancies; chest tightness (3.1%); and the very rare occurrences (0.8% each) of haemoptysis (coughing up blood), wheezing sounds, chest heaviness, and sore throat, as shown in **Table 2**. The low frequency of these latter symptoms suggests they are less typical presentations of the ILDs observed in this cohort.

Table 3 shows that over half of the participants (56.3%) reported no specific occupational or environmental exposure. This could indicate the presence of idiopathic ILDs (those with unknown causes) or suggest that exposures were not adequately captured by the questionnaire. Occupational dust was the most frequently reported exposure (18.8%), highlighting the importance of occupational history in the evaluation of ILD. Asbestos and silica exposure, known risk factors for asbestosis and silicosis, respectively, were reported by 5.5% of participants each. Other less frequent exposures included bird protein (4.7%), which can be associated with hypersensitivity pneumonitis, farming-related dust (3.1%), also a risk factor for hypersensitivity pneumonitis (farmer's lung), and various other specific exposures each reported by less than 1% of the study population. The low prevalence of these specific exposures emphasizes the multifactorial nature of ILD and the difficulty in identifying a single causative agent in many cases.

Analysis of the relationship between predominant HRCT patterns and final diagnoses in **Table 4** revealed distinct and clinically relevant associations. Among patients with a UIP pattern on HRCT, the majority (77.8%) were diagnosed with IPF. This strong association reinforces the established diagnostic criteria for IPF, where a UIP pattern on HRCT is a key diagnostic feature. This high positive predictive value of UIP for IPF is a crucial finding for clinicians. In contrast, NSIP and HP patterns were more frequently associated with diagnoses of NSIP (75.9%) and HP (70.5%), respectively. These findings confirm the diagnostic utility of HRCT in differentiating these common ILD subtypes. The organizing pneumonia pattern was associated with a diagnosis of organizing pneumonia in 75% of the cases, and the DIP pattern was associated with DIP in 66.7% of the cases, further supporting the correlation between HRCT findings and specific ILD diagnoses. While other less frequent associations were observed, the strong associations described above are the most clinically significant.

In the short term, most patients experienced positive outcomes, with symptom improvement reported by 81.0% and stabilization of lung function as measured by PFTs in 79.5%. However, it's important to note that a subset of patients experienced disease progression on HRCT (14.4%) and/or some form of complication (21.5%). The findings of **Table 5** underscore the variable course of ILD and the need for ongoing monitoring.

Long-term follow-up revealed a generally favourable prognosis, with a high survival rate (86.7%) and only 13.3% of participants deceased. Among the surviving patients, the majority had stable disease (73.4%), but a notable proportion (18.0%) experienced disease progression. The fact that 23.4% of patients required advanced therapies highlights the significant morbidity associated with ILD and the need for effective treatment strategies as shown in **Table 6**.

The strong associations between specific HRCT patterns (UIP, NSIP, HP, organizing pneumonia, DIP) and their respective diagnoses shown in **Table 7 & 8**, as demonstrated in this study, reinforce the

crucial role of HRCT in the diagnostic workup of ILD. These findings provide valuable information for clinicians in interpreting HRCT scans and making informed diagnostic and management decisions.

Table 1 : Demographic Characteristics of Study Participants (Corrected)

Characteristic	N (128)	Percentage (%)
Age (years)		
Mean ± SD	47.9 ± 14.2	
Range	17-85	
Gender		
Male	70	54.7
Female	58	45.3
Smoking Status		
Never Smoked	66	51.6
Former Smoker	16	12.5
Current Smoker	46	35.9

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Table 2: Frequency of Presenting Symptoms

Symptom	Frequency	Percentage (%)
Chronic Cough	117	91.4
Dyspnea	121	94.5
Fatigue	80	62.5
Chest Pain	89	69.5
Weight Loss	41	32.0
Fever	25	19.5
Night Sweats	9	7.0
Malaise	16	12.5
Hemoptysis	1	0.8
Wheezing sounds	1	0.8

Chest tightness	4	3.1
Chest heaviness	1	0.8
Sore throat	1	0.8

Table 3: **Frequency of Reported Exposures**

Exposure	**Frequency (128)**	**Percentage (%)**
No Exposure	72	56.3
Occupational Dust	24	18.8
Asbestos	7	5.5
Silica	7	5.5
Bird Protein	6	4.7
Farmer (Occupational dust)	4	3.1
Occupational dust related allergy	1	0.8
Cold weather-related allergy causing SOB	1	0.8
Pet exposure	1	0.8
Exposure of drugs (cocaine)	1	0.8
Occupational dust from house chores	1	0.8
Exposure to chemicals	1	0.8
Coal dust exposure	1	0.8
Silica exposure	1	0.8

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Table 4: Number of Patients with Specific HRCT Patterns by Final Diagnosis

Final Diagnosis	**UIP (n=36)**	**NSIP (n=54)**	**HP (n=44)**	**Organizing Pneumonia (n=12)**	**DIP (n=3)**	**Atypical Pneumonia (n=2)**	**Sarcoidosis (n=2)**	**Asbestosis (n=2)**	**Silicosis (n=2)**	**Other/ Unspecified (n=5)**
IPF	77.80 %	5.60%	4.50%	0%	0%	0%	0%	0%	0%	20%
NSIP	11.10	75.90%	15.90%	8.30%	33.30%	0%	0%	0%	0%	20%
HP	8.30%	13.00%	70.50%	25%	0%	0%	0%	50%	50%	0%

Organizing Pneumonia	0%	0%	0%	75%	0%	50%	0%	0%	0%	0%
DIP	0%	1.90%	0%	0%	66.70%	0%	0%	0%	0%	0%
Atypical Pneumonia	0%	0%	0%	0%	0%	50%	0%	0%	0%	0%
Sarcoidosis	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%
Asbestosis	0%	0%	2.30%	0%	0%	0%	0%	50%	0%	0%
Silicosis	0%	0%	2.30%	0%	0%	0%	0%	0%	50%	0%
Other	2.80%	3.70%	4.50%	0%	0%	0%	0%	0%	0%	0%

Table 5: Short-Term Outcomes

Outcome	Yes	No	Total
Symptom Improvement	98	30	121
Stabilization of Lung Function (PFTs)	93	34	117
Progression on HRCT	17	111	118
Any Complications	26	102	121

Table 6: Long-Term Outcomes

Outcome	Count	Percentage (%)
Survival Status (Alive)	111	86.7
Survival Status (Deceased)	17	13.3
Disease Progression (Stable)	94	73.4
Disease Progression (Worsened)	23	18.0
Need for Advanced Therapies	30	23.4

Table 7: Short-Term Symptom Improvement by Final Diagnosis

Diagnosis	Symptom Improvement (Yes)	Symptom Improvement (No)
IPF	21	6
NSIP	31	14
HP	27	10
Organizing Pneumonia	9	1

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DIP	3	0
Atypical pneumonia	1	0
Sarcoidosis	2	0
Asbestosis	2	0
Silicosis	1	0

Table 8 : Long-Term Survival by Predominant HRCT Pattern

HRCT Pattern	Alive	Deceased	Total
UIP	33	9	42
NSIP	56	9	65
HP	37	6	43
Organizing pneumonia	10	0	10
DIP	3	0	3
Sarcoidosis	2	0	2
Asbestosis	2	0	2
Silicosis	1	0	1

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DISCUSSION

This study aimed to investigate the role of high-resolution computed tomography (HRCT) in the diagnosis and management of interstitial lung diseases (ILDs) in a cohort of 128 patients. ILDs comprise a heterogeneous group of lung disorders characterized by the progressive accumulation of scar tissue within the lung parenchyma, leading to impaired gas exchange and significant respiratory disability.[11] Our findings demonstrate the pivotal role of HRCT in the diagnostic workup of ILDs, emphasizing its ability to accurately characterize specific patterns of lung involvement and guide subsequent clinical management.

The study population exhibited a diverse demographic profile, with a mean age of 47.9 years (SD = 14.2) and a slight male predominance. This age range reflects the broad spectrum of ILDs, which can affect individuals across different age groups. Smoking history varied significantly, with 51.6% of patients never smokers, 12.5% former smokers, and 35.9% current smokers. Smoking is a well-established risk factor for several ILDs, including idiopathic pulmonary fibrosis (IPF) and respiratory bronchiolitis-associated ILD (RB-ILD). [11]

Dyspnea (94.5%) and chronic cough (91.4%) were the most prevalent presenting symptoms, reflecting the significant respiratory morbidity associated with ILDs. Other common symptoms included chest pain (69.5%), fatigue (62.5%), and weight loss (32.0%). These findings align with previous studies that have identified dyspnea and cough as the cardinal presenting symptoms in ILD. [12] The presence of chest pain and fatigue highlights the systemic effects of these conditions, extending beyond the respiratory

system to affect overall well-being and functional capacity.

Occupational and environmental exposures were assessed, with occupational dust exposure being the most frequent (18.8%). Exposure to asbestos and silica, known risk factors for asbestosis and silicosis, was reported in 5.5% of participants. Other exposures included bird protein (4.7%), a known trigger for hypersensitivity pneumonitis, and farming-related dust (3.1%).[13] These findings emphasize the importance of a detailed occupational and environmental history in the evaluation of patients with suspected ILD.

The core finding of this study was the strong correlation between specific HRCT patterns and final diagnoses. 77.8% of patients with a UIP pattern on HRCT were diagnosed with IPF, supporting the diagnostic criteria for IPF, which considers UIP a key feature. [14, 15] Similarly, significant associations were observed between the NSIP pattern and a diagnosis of NSIP (75.9%) and between the HP pattern and a diagnosis of HP (70.5%). These findings underscore the crucial role of HRCT in differentiating ILD subtypes. [16]

Short-term outcomes demonstrated symptom improvement in 81.0% of patients and stabilization of lung function in 79.5%. However, 14.4% experienced disease progression on HRCT, and 21.5% developed complications. Long-term outcomes revealed a high survival rate (86.7%), but 18.0% of patients experienced disease progression, and 23.4% required advanced therapies, highlighting the variable and often progressive nature of ILDs. [17-20]

This study has limitations, including its single-center design and the potential for selection bias. The use of convenient sampling may have introduced a bias in the patient population. Furthermore, the lack of histopathological confirmation in all cases is a limitation, as it is considered the gold standard for diagnosis in certain ILD subtypes, although it is not always feasible or clinically indicated.

Future research should address these limitations by conducting larger, multicenter studies with histopathological correlation to further validate the diagnostic accuracy of HRCT. The application of advanced imaging techniques, such as ultra-high-resolution CT and artificial intelligence-based image analysis, holds significant promise for enhancing diagnostic accuracy, predicting disease progression, and personalizing treatment strategies. [20]

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CONCLUSION

HRCT plays a integral role in the diagnosis and management of ILD. This study reveals strong associations between specific HRCT patterns—UIP, NSIP, HP, organizing pneumonia, and DIP—and their corresponding diagnoses, supporting the established utility of HRCT in suggesting specific ILD subtypes.

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