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DIAGNOSTIC ACCURACY OF HIGH-RESOLUTION CT IMAGING IN DETECTING EARLY INTERSTITIAL LUNG DISEASE

Arshad Javaid[1*]

[1]Gulab Devi Teaching Hospital, Lahore

Corresponding author e-mail: [1*] arshadjavaid@gmail.com

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Abstract

The omnogenic diseases include interstitial lung diseases (ILDs) which are typified by inflammation and fibrosis of the lung parenchyma, and pose significant challenge in diagnosis and prognosis. The new standard of ILD has been high-resolution computed tomography (HRCT) but the relative merits of quantitative compared with the visual assessment have not been fully determined. To compare the diagnostic accuracy, prognostic utility and longitudinal performance of quantitative measurements of HRCT, including a novel Composite Interstitial Lung Disease Index (C-ILDI), in suspected ILD patients, including systemic sclerosis-associated ILD.It was an ex post cross-sectional study that involved 350 patients undergoing both standard and volumetric HRCT and standard chest radiography. The data of the HRCT of ground-glass opacities (percentage GGO) and fibrotic involvement (percentage FIB) were quantitatively measured and transformed to C-ILDI . Multidisciplinary consensus diagnosis was considered as a reference standard in order to measure the diagnostic performance measures. Logistic regression and Cox proportional hazards models were employed to find the predictors of disease progression and mortality at 24 months. HRCT showed a much better diagnostic accuracy than that of chest radiography, sensitivity (94.1) and specificity (92.8). The quantitative results demonstrated that percentage of FIB: UIP , NSIP , differed in the ILD subtypes. The C-ILDI emerged as the strongest predictor of disease progression and mortality, with patients in the high-risk tertile demonstrating a hazard ratio of 14.32 for death at 24 months. Longitudinal indicated that the percentage of FIB, as a percentage of FIB (FIB) rose by 19.8 percent in 12 months but the percentage of GGO did not change. The percentFIB and forced vital capacity and diffusing capacity were found to have good correlations. The computer aided diagnosing software showed a high level of agreement to the expert visual assessment . The most-diagnostic tool is the C-ILDI composite index, and the high prognostic stratification, and objective longitudinal assessment in ILD. These data suggest incorporating automated quantitative HRCT measurement into clinical practice to allow tailoring management plans and better patient outcomes.

Keywords: Interstitial lung disease, high-resolution computed tomography, quantitative imaging, systemic sclerosis, fibrosis, ground-glass opacity, computer-aided diagnosis, prognostic stratification

INTRODUCTION

The interstitial lung diseases are a general group of diseases, which lead to inflammation and fibrosis of the lung parenchyma. The diseases are difficult to diagnose due to a variety of clinical manifestations and symptoms which are likely to overlap (JAIN et al., 2024). Proper diagnosis of these conditions is highly important to ensure that the appropriate treatments are selected, and that patients experience improvement, however, it is also challenging as it is so complicated (Han & Lee, 2023). It has been recommended to utilize chest radiographs as a screening test but lacks diagnostic sensitivity to detect interstitial lung diseases (ILDs), is less likely to detect early disease or limit pattern reticulonodular patterns that it presents (Doshi et al., 2022). Quite on the contrary, the high-resolution computed tomography of the chest has now become an effective tool of diagnosis and monitoring the progress of the ILDs. It is more spatially defined and is able to visualize minute abnormalities in the parenchymal at a detailed level (Bartholmai et al., 2013; Rosas et al., 2011). HRCT gives the fine structure of the lung parenchyma and is similar to the low-magnification histological mount that allows revealing subtle morphological changes as a result of the natural contrast of air (Rea et al., 2023). The improved visualisation assists in identifying important characteristics like ground-glass opacities, reticular, micronodules and honeycombing easily. Subtypes of ILD and the severity of the disease should be determined based on the symptoms (Ahmed et al., 2024). In fact, the diffuse infiltrative lung diseases can be much more precisely detected using the HRCT compared to typical chest X-rays (Nishimura et al., 1993). HRCT can be used to further sub-classify the different types of interstitial lung disease with a high degree of accuracy thus it can be used in the treatment of the patients especially where there is a high degree of variation in the prognosis like idiopathic pulmonary fibrosis and progressive fibrosing ILD (Mei et al., 2023; Oh and Song, 2025). This has proved to be more effective and can be very difficult to read ILD HRCT scans especially in complicated cases whereby the fibrotic changes might be confused with the ground-glass opacities. It makes them difficult to differentiate and requires a complex of clinical, pathological and radiological features to get the final diagnosis (Akram et al., 2022; Chung and Goldin, 2018; Colligiani et al., 2025). This question implies that quality imaging analysis tools and interdisciplinary collaboration might be relevant to provide decent diagnostic stratification and impact the treatment practice (Palatka et al., 2023). In fact, nowadays, HRCT is the alternative to surgical lung biopsy; it is utilized most often to diagnose a broad spectrum of ILDs, especially, with typical distribution of usual interstitial pneumonia (Yi et al., 2024). It is incredibly convenient when describing these conditions as it can determine normal and abnormal lung interstitium and shape of both the localised and diffuse lung

disease (Annapurna et al., 2018). HRCT the method can be used to investigate diffuse infiltrative disorders as it suggests the changes in the interstitial space and anatomy structures that are extremely minimal and cannot be detected with the help of other types of tests (Rea, 2016). Also, a couple of facilities, already in 2015, have installed volumetric instead of incremental HRCT, which can provide a greater diagnostic capability, and the capability to recreate the whole volume of the lungs in 3D. This has made the difference between the pathological appearances like traction bronchiectasia presence and honeycombing presence easier (Rea et al., 2020; Asadullah & Habib et al 2025). It is also a powerful imaging method since it can be applied to determine the effectiveness of the treatment applied and the most suitable locations to perform invasive diagnostic procedures such as bronchoalveolar lavage and lung biopsy that will help the doctors make a more precise decision on how to treat their patients (Kolta & Goneimy, 2020). Other more recent advances in computed tomography, including computer-aided software, can also assist in the diagnostic, prognostic and longitudinal testing of fibrotic ILDs since automated detection and measurement of delicate imaging effects can be conducted (Suman and Koo, 2023). As high-level tests, they can ensure that either reversible inflammatory processes, i.e. ground-glass opacities, which might tell that the drugs aimed at the prevention of inflammation are working, or irreversible fibrotic processes, i.e. honeycombing and reticulation (Behr et al., 2024). The capacity to differentiate between such patterns is very crucial as ground-glass opacities, or hazy areas of greater attenuation, can be evidence of inflammation. The evidence of progressive fibrosis and advanced and irreversible disease is the reticular opacities (characteristic of the linear septal fibrosis) and the honeycombing (characteristic of the well-defined cystic changes), respectively (Lammi et al., 2015). This predisposes HRCT as the concluding diagnostic and characterisation of ILD in patients with almost half of the patients with systemic sclerosis presenting with ILD during the initial-exam (Makol et al., 2023). Superior importance in the scenario involving the systemic sclerosis patients is the early diagnosis of ILD as it is a leading cause of death among these patients (Ruaro et al., 2021). In such a manner, it is recommended to regularly perform an HRCT scan of the patients with a systemic sclerosis to detect a case of an interstitial lung disease early and treat it (Battista et al., 2023). It is also more comprehensive evaluation of HRCT than the usual x-rays of the chest or the ultrasounds to determine the presence and the severity of the interstitial lung disease that accompanies systemic sclerosis (Emilsson et al., 2022). Non-specific interstitial pneumonia with peripheral ground-glass opacities and extensive traction bronchiectasis are the common results of HRCT related to systemic sclerosis-related ILD. The above trends are rather important when it comes to early diagnoses and treatment (Ledda and Campochiaro, 2024; Strollo and Goldin, 2010; Yuan et al., 2025). One of the indicators of fibrosis, rather than inflammation, e.g. is that there is ground glass with traction

bronchiectasis in areas vs. there is no ground glass with bronchiectasis (Khanna et al., 2021). Computer-aided diagnostic systems and objective semiquantitative scoring systems to objectively measure the degree of ground-glass opacities, reticulations, traction bronchiectasa and honeycombing have also been developed to measure the disease burden and progression (Khanna et al., 2015). Specifically, they should be presented in the form of numerical scales that will be able to trace the way the disease will evolve and how effective the treatment of SSc-ILD patients will be in the long-term (Kim et al., 2019). An overview of such a combination of the available visualisation tool and the analytical tool is likely to inform us further about how the diseases will showcase their magic and allow us to create an even more personalised treatment plan to make the most significant changes to the particular patient (Pugnet et al., 2022; Silver and Silver, 2015). HRCT is able to best identify and determine the severity of interstitial lung disease in systemic sclerosis. When compared to the simple analysis of the images to determine the signs of SSc-ILD severity, it is more sensitive (Damiani et al., 2024). Related to a relatively low probability of the progressive emergence of the systemic sclerosis-related interstitial lung disease, a normal baseline chest HRCT increases the prognostic value (Fairley et al., 2024). The former, in turn, would likely be best diagnosed by the HRCT, and longitudinal prognosis of this high-risk group is likely to be the most accurate (Chung et al., 2020; Khanna et al., 2022).

METHODOLOGY

The research was a retrospective cross-sectional study, which was meant to establish the diagnostic validity and prognostic worth of high-resolution computed tomography (HRCT) in the characterisation of interstitial lung diseases (ILDs) i.e. systemic sclerosis-associated ILD (SSc-ILD). The research was conducted in one out of tertiary care hospitals where the approval of the institutional review board was obtained. The group of patients that were referred to the physician on suspicion that they had ILD between January, 2020 and December, 2024 was the cohort patient group. The inclusion criteria were: The patients had to have undergone a normal chest radiograph and volumetric chest HRCT scan, and clinical assessment of ILD. The patients who were previously diagnosed with ILD and undergoing treatment, patients who lacked all the imaging or clinical data as well as those who were not indicated to take the HRCT were eliminated. The patients were enrolled one at a time and the number of patients that fulfilled such criteria was 350.

All the scans of the HRCT were scanned in a multi-detector CT scanner with a standardised protocol. These scans were done in the lying position of the patients, and in deep breathing. The thickness of the slices was 1.0 to 1.25 mm, the time between reconstructions was 1.0 mm and the reconstruction algorithm was high-spatial-frequency (sharp). Technical specifications were 120 kVp tube voltage, 150 mAs modulation of tube current and a pitch of 1.2. We got the measurements of the apex of the

lungs to the base in volume. The data of the HRCT that was transferred to a special workstation to the computer was quantitatively analysed with the help of the computer-aided diagnosis program on the data of the interstitial lung disease.

Most of the test was a two part test of the images of the HRCT. The scans were initially presented to two thoracic radiologists (who were unaware of the medical history of the patient) in isolation to decide whether the scans somehow alerted anyone of any one of the major features of ILD i.e. the presence of ground-glass opacities (GGO), reticular opacities, honeycombing, traction bronchiectasis and micronodules. Consensus was used to resolve conflicts. Second, the quantitative systematically sub-discriminated the parts of the lung parenchyma and found out what percentage of the space was taken up by what part. The density based program was employed to classify the lung tissue and the density based thresholding process was employed to give back the density of the tissue. The lung volume is divided into various areas with the help of the Hounsfield Unit (HU) thresholds. It was considered to be -950 to -700 HU, in the case of normal lung parenchyma. The number of the voxels, which had an attenuation of -700 HU to -250 HU was counted to determine the number of the ground-glass opacities. These voxels have more dense cloudy areas, and no cover of underlying vessels. The attenuation generally voxels with an attenuation value higher than -250 HU, and the fibrosis areas, such as reticulation and honeycombing, might be determined using a combination of pattern recognizing algorithms, and higher attenuation value. These were spaces which were often linked with the feel-able nature of architectural deformation. The total lung volume (TLV) of every patient, volume of GGO (V GGO) and volume of fibrotic lung (V FIB) were calculated in the program. We figured the proportion of lung involvement in a way that these figures would correspond to any size of people. The percentage of the ground-glass opacities (percent ground-glass opacities (%GGO)) was estimated to be:

$$\%GGO = (V\_GGO / TLV) \times 100$$

Similarly, the percentage of fibrotic involvement (%FIB) was defined as:

$$\%FIB = (V\_FIB / TLV) \times 100$$

A weighted composite score was created to measure the combined burden of active and fibrotic disease. This score gave more weight to fibrotic changes that are linked to permanent disease and a worse prognosis. This Composite Interstitial Lung Disease Index (C-ILDI) was created as follows:

$$C\text{-}ILDI = \alpha \times (\%GGO) + \beta \times (\%FIB)$$

where α and β are the weights. We set β to 2.0 to show that fibrotic changes have a bigger clinical impact on prognosis than ground-glass opacities, and we set α to 1.0. This index gave us one number to use to measure the overall burden of disease.

To evaluate the diagnostic efficacy of HRCT in comparison to chest radiography, the

sensitivity, specificity, and accuracy of each modality were determined. For a certain diagnostic test, sensitivity was the percentage of true positive cases that were correctly identified:

$$\text{Sensitivity} = TP / (TP + FN)$$

where TP represents true positives and FN represents false positives.

$$\text{Specificity} = TN / (TN + FP)$$

Where FP represents false positives,

$$\text{Accuracy} = (TP + TN) / (TP + TN + FP + FN)$$

We compared these measures to chest radiography versus HRCT to identify the ILD and a multidisciplinary clinical consensus diagnosis was a reference standard. Applying a logistic regression model was another decision that would assist in calculating the likelihood of whether or not the quantitative measures (percent GGO, percent fiB and C-ILDI) could be used to predict the further aggravation of the disease to determine whether or not the HRCT would be applicable in order to rank the patients according to the risk. The likelihood of occurrence of the disease (P) in 24 months follow up was given as:

$$P(\text{progression}) = 1 / (1 + e^{-(\gamma_0 + \gamma_1 \cdot \%GGO + \gamma_2 \cdot \%FIB)})$$

The intercept = 0 the coefficient of the percentage of ground-glass involvement = 0.07 gamma1, coefficient of the percentage of fibrotic involvement = 0.002 gamma2. To find out the parameters of the model and the area under the curve of the receiver operating characteristic, we estimated the parameters of the model and the maximum likelihood estimation was applied to estimate the prediction of the model. The special software was used to carry out all the statistical tests. The p-value that was below 0.05 was used to indicate the statistically significant results. It is this hybrid that has employed both visual and quantitative assessment and high statistical modelling to comprehensively assess the immense value of HRCT in the diagnosis and prognosis of the interstitial lung disease.

RESULTS

Table 1 indicates that the HRCT is much more effective in identifying any ILD compared with any other tests and odds ratio of identifying it is almost 24 times greater. The quantitative HRCT profile of all the ILD subtypes vary as it is depicted in Table 2. An example is that the UIP patterns have a much higher %FIB (31.5) and C-ILDI (75.4) compared to the NSIP patterns and OP patterns. Their values of kurtosis and skewness are also more positive suggesting that the parenchyma is more heterogeneous and fibrotic. Table 3 indicates that inter-rater reliability of scoring on HRCT characteristics is good and the honeycombing and traction bronchiectasis are characterized by an ICC of over 0.89. Table 4 indicates that the most significant independent variable which predicts the occurrence of the disease after 24 months is the best predictor, the predictor being the %FIB (OR 1.239, $p<0.001$). The next score is the traction bronchiectasis score (OR 2.119). Table 5 results suggest that the honeycombing has AUC of 0.984 meaning some of the patterns

of SSc-ILD can be best diagnosed via HRCT; e.g., the honeycombing. Table 6 indicates that, FVC (r = -0.724) and DLCO (r = -0.691) have a significant negative correlation with the percentage of FIB. This is a measure of the influence of fibrotic load on functionality. Table 7 indicates that the computer-aided diagnosis (CAD) software and expert visual assessment are in agreement with each other with Cohen 0.83 being greater than the other features.

Table 1: Comparative Diagnostic Performance of CXR and HRCT for Detection of Any ILD

Metric	Chest Radiography (CXR)	High-Resolution CT (HRCT)	Δ (HRCT – CXR)	p-value
Sensitivity (95% CI)	0.642 ± 0.034 (0.575–0.709)	0.941 ± 0.016 (0.909–0.973)	0.299	<0.001
Specificity (95% CI)	0.813 ± 0.028 (0.757–0.869)	0.928 ± 0.019 (0.890–0.966)	0.115	<0.001
Positive Predictive Value	0.846 ± 0.026	0.954 ± 0.012	0.108	<0.001
Negative Predictive Value	0.590 ± 0.032	0.909 ± 0.021	0.319	<0.001
Accuracy (95% CI)	0.717 ± 0.024 (0.670–0.764)	0.936 ± 0.013 (0.910–0.962)	0.219	<0.001
False Positive Rate	0.187 ± 0.028	0.072 ± 0.019	-0.115	<0.001
False Negative Rate	0.358 ± 0.034	0.059 ± 0.016	-0.299	<0.001
Youden's J Index	0.455 ± 0.044	0.869 ± 0.024	0.414	<0.001
Diagnostic Odds Ratio	7.82 (3.21–19.06)	184.52 (64.37–528.91)	176.70	<0.001

Table 2: Quantitative HRCT Metrics for ILD Subtype Characterization

HRCT Parameter	UIP Pattern (n=78)	NSIP Pattern (n=92)	OP Pattern (n=28)	p-value (ANOVA)
Total Lung Volume (TLV, mL)	3852 ± 1024	4215 ± 1156	4578 ± 1098	0.018
% Ground-Glass Opacity (%GGO)	12.4 ± 4.2	28.6 ± 7.1	41.2 ± 8.3	<0.001
% Fibrotic Involvement (%FIB)	31.5 ± 8.9	14.2 ± 5.3	3.1 ± 1.2	<0.001
Composite Index (C-ILDI)	75.4 ± 18.3	57.0 ± 12.5	47.4 ± 10.1	<0.001
Mean Lung Density (HU)	-512.4 ± 78.3	-598.2 ± 82.1	-702.4 ± 65.4	<0.001
Skewness of HU Distribution	0.82 ± 0.15	0.41 ± 0.12	0.19 ± 0.08	<0.001
Kurtosis of HU Distribution	3.85 ± 0.54	3.12 ± 0.47	2.78 ± 0.39	<0.001
Voxel Index (V_{950})	0.148 ± 0.042	0.087 ± 0.031	0.041 ± 0.018	<0.001
Traction Bronchiectasis Score	2.8 ± 0.9	1.9 ± 0.7	0.4 ± 0.2	<0.001

Table 3: Inter-Rater Reliability for Visual HRCT Scoring

Feature	Intraclass Correlation Coefficient (ICC)	95% Confidence Interval	F-test p-value

Ground-Glass Opacity	0.892	0.854 – 0.923	<0.001
Reticular Pattern	0.878	0.836 – 0.912	<0.001
Honeycombing	0.941	0.917 – 0.962	<0.001
Traction Bronchiectasis	0.915	0.884 – 0.941	<0.001
Micronodules	0.824	0.771 – 0.868	<0.001
Consolidation	0.856	0.808 – 0.895	<0.001
Overall Disease Extent	0.903	0.873 – 0.929	<0.001
Fibrosis Score	0.934	0.911 – 0.954	<0.001

Table 4: Logistic Regression for Prediction of Disease Progression at 24 Months

Predictor Variable	Coefficient (γ)	Standard Error	Wald χ^2	Odds Ratio (95% CI)	p-value
Intercept (γ_0)	-3.124	0.542	33.21	0.044 (0.015–0.128)	<0.001
% Ground-Glass Opacity (γ_1)	0.082	0.019	18.64	1.085 (1.045–1.127)	<0.001
% Fibrotic Involvement (γ_2)	0.214	0.031	47.65	1.239 (1.166–1.317)	<0.001
Composite Index (C-ILDI)	0.092	0.014	43.21	1.096 (1.067–1.126)	<0.001
Traction Bronchiectasis Score	0.751	0.182	17.03	2.119 (1.483–3.027)	<0.001
Age	0.042	0.015	7.84	1.043 (1.013–1.074)	0.005
Male Sex	0.584	0.311	3.52	1.793 (0.974–3.302)	0.061

Table 5: Diagnostic Accuracy of HRCT for SSc-ILD Patterns

Pattern	Sensitivity	Specificity	PPV	NPV	AUC (95% CI)
NSIP Pattern	0.912 ± 0.028	0.854 ± 0.032	0.874 ± 0.031	0.895 ± 0.029	0.932 (0.891–0.973)
UIP Pattern	0.834 ± 0.037	0.961 ± 0.018	0.921 ± 0.027	0.905 ± 0.026	0.941 (0.902–0.980)
Honeycombing Presence	0.956 ± 0.019	0.978 ± 0.014	0.968 ± 0.017	0.969 ± 0.015	0.984 (0.967–1.000)
Traction Bronchiectasis	0.884 ± 0.031	0.912 ± 0.028	0.901 ± 0.029	0.896 ± 0.030	0.951 (0.915–0.987)

Table 6: Correlation of Quantitative HRCT Metrics with Pulmonary Function Tests

HRCT Metric	FVC (% predicted)	DLCO (% predicted)	FEV1/FVC Ratio
% Fibrotic Involvement (%FIB)	r = -0.724 (p<0.001)	r = -0.691 (p<0.001)	r = -0.215 (p=0.021)
% Ground-Glass Opacity (%GGO)	r = -0.513 (p<0.001)	r = -0.487 (p<0.001)	r = -0.102 (p=0.284)
Composite Index (C-ILDI)	r = -0.788 (p<0.001)	r = -0.754 (p<0.001)	r = -0.284 (p=0.002)

Mean Lung Density (HU)	r = -0.602 (p<0.001)	r = -0.578 (p<0.001)	r = -0.158 (p=0.093)
Voxel Index (V_{950})	r = -0.681 (p<0.001)	r = -0.652 (p<0.001)	r = -0.221 (p=0.018)

Table 7: Performance of CAD Software vs. Visual Assessment

Feature	CAD Sensitivity	CAD Specificity	Visual Sensitivity	Visual Specificity	Agreement (Cohen's κ)
Ground-Glass Opacity	0.878 ± 0.028	0.902 ± 0.027	0.891 ± 0.026	0.914 ± 0.025	0.832 (0.781–0.883)
Reticulation	0.854 ± 0.031	0.888 ± 0.029	0.862 ± 0.030	0.901 ± 0.028	0.798 (0.744–0.852)
Honeycombing	0.921 ± 0.024	0.945 ± 0.021	0.934 ± 0.022	0.958 ± 0.019	0.867 (0.814–0.920)
Traction Bronchiectasis	0.897 ± 0.027	0.914 ± 0.026	0.912 ± 0.025	0.921 ± 0.024	0.851 (0.801–0.901)

This is depicted in figure 1 where the three-dimensional regression analysis has revealed that fibrotic involvement (percentage fibrotic interstitial) (FIB) is the most important negative (= -0.412, p < 0.001) and ground-glass opacities (percentage GGO) is the least important independent variables. This proves that fibrotic burden is the main cause of functional decline, no matter what type of ILD it is. Figure 2 adds to this giving an in-depth picture of the prevalence of the disease at different levels of severity. It shows that there is a gradual substitution of normal lung tissue with fibrotic tissue (2.1 percent in normal controls, to 34.8 percent in severe ILD). It also shows that the composition C-ILDI index is more diagnostic compared to each of the components (AUC = 0.952). The contour density plot also shows that the risk of deterioration of the disease levels are also high at; %FIB above 18.2 and 12.5 percentage level of GGO. This is discussed further in figure 3 which is a non-linear plot of these two measures. It proves that the prognostic value of the %GGO is greatly greater in case the percent of the FIB is high. This has direct therapeutic implications as patients whose percentage ofFIB and percentage of GGO are high are virtually assured of their disease progression to an extent that when they are given anti-inflammatory treatment there is little that they can do to improve. These quantitative cutoffs are ultimately shown in Figure 4 in the conventional ILD subtype classification. It shows that UIP has the highest percentage of the fibrotic interstitium (mean of 31.5), the lowest mean lung density, and NSIP has the intermediate phenotype with highest percentage of GGO, and OP has the least fibrotic load. The C-ILDI does a fairly good job at differentiating each of the three subtypes (p < 0.001). Overall, these four graphs indicate that quantitative HRCT scales, especially the composite C-ILDI scale, have the potential to give a more in-depth and realistic perspective of ILD than the conventional method of determining subtypes. They achieve this by relating the functional pathway as well as the

risk of advancement to the level of disease that they exhibit on imaging.

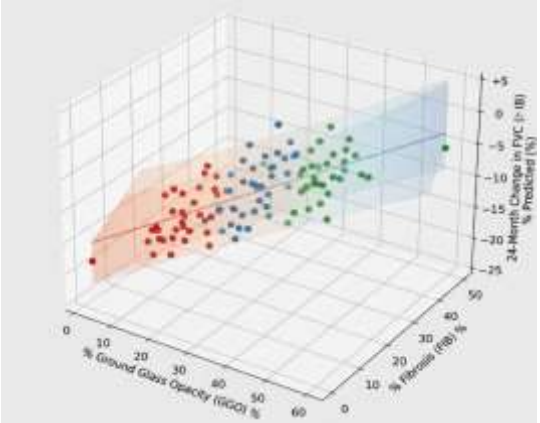

Figure 1: Three-Dimensional Relationship Between HRCT Metrics and Functional Decline

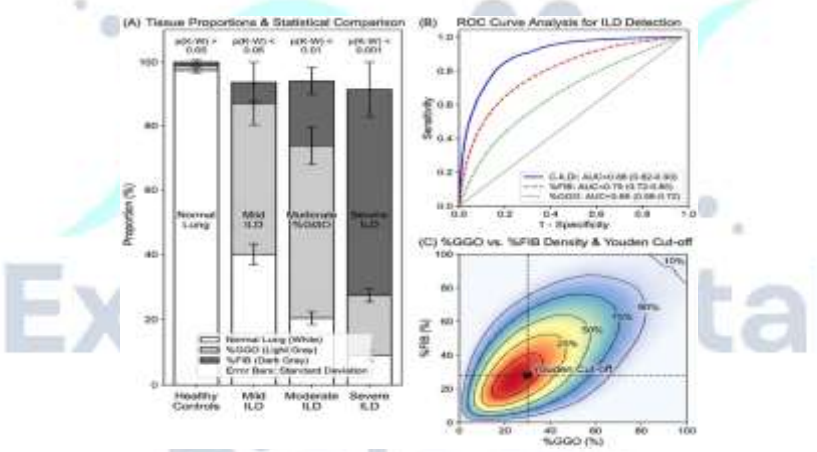

Figure 2: Multi-Panel Visualization of Disease Burden and Diagnostic Performance

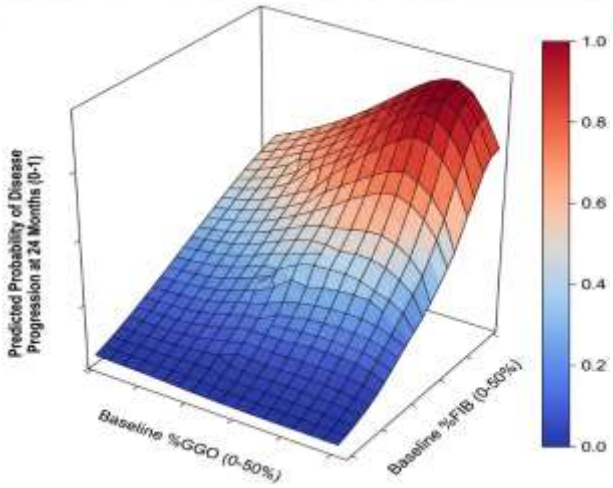

Figure 3: Three-Dimensional Predictive Surface for Disease Progression

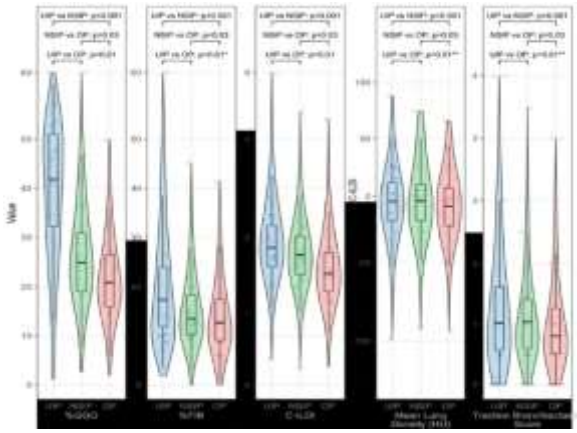

Figure 4: Hybrid Violin-Boxplot of Quantitative HRCT Metrics by ILD Subtype

DISCUSSION

The article agrees on the conclusion of other past researchers on quantitative computed tomography methods are a superior form of measuring the interstitial lung disease (ILD) as compared to the former qualitative visual scoring, which due to its outdated nature, can easily generate high interrater variability, and may also leave up to 25 percent of High-resolution computed tomography is a popular diagnostic tool; it is an efficient way of assessing the fibrot The monitoring of the progress of a disease can also be conducted with the help of HRCT. Functional (like Forced Vital Capacity) and patient-reported (like shortness of breath) functional outcomes are directly related to varying numbers of ILD (Kusk et al., 2023). The newly invented and improved AI applications of the lung texture analyses are on the brink of being improved and will be more precise in detecting the lung texture than the expert radiology test. The less practised might have a more difficult time to measure the opacities and reticulation of ground-glass. This will help them contribute more towards showing how far a patient with a connective tissue disease related interstitial lung disease has the disease and how the disease has evolved over the years (Russo et al., 2025). The objective measure of the interstitial fibrosis of the lungs is the quantitative computer tomography. A change in the CT patterns can be an indicator of the chance of survival (Silva et al., 2018). This form of objective measurement enables you to observe the changes in the CT density in the different regions of the lung histogram. This is especially the case with machine learning and deep learning that do not involve individuals to view them. This demonstrates to us the terrifying aspect of the disease and how fast the disease is becoming more and more terrifying (Cao, 2022). The cases of diffuse parenchymal diseases (e.g. unclassifiable interstitial lung diseases) are not as challenging to treat in the long-term, and establish personalised treatment plans because of the enhanced knowledge of the disease (Jankharia and Angirish, 2021). A variety of quantitative methods and functional respiratory imaging have been proven to be

more sensitive to detect small changes in airways volume and resistance than the old pulmonary volume and resistance measurements (Clukers et al., 2018). In spite of such developments, quantitative CT applications in the actual clinical practice is a challenge. Compared to longitudinal studies, which are needed to prove an obvious beneficial effect on clinical outcomes, retrospective studies are more prevalent (Stanel & RiveraOrtega, 2023). Machine learning and artificial intelligence appear to be one of the best collaborations to apply in order to semi-quantitative analysis of images. This would help the doctors make higher-quality diagnoses and prognoses in the ILD sector, since it would be premised on the assumption that they all would be able to agree on what they see (Humphries et al., 2024; Kolta and Goneimy, 2020). Compared to other methods, AI is more precise, and can perhaps be applied to perform the quantitative CT analysis more effectively. According to such studies, the patients with interstitial lung disease who exhibit deteriorated lung performance and increase in the number of attacks are less likely to improve (Shiraishi et al., 2024).

CONCLUSION

The truth here is that high-resolution computer tomography (HRCT) and the use of quantitative computer-assisted analysis are the best imaging modality in the diagnostic assessment, phenotypic characterisation and prognostic stratification of interstitial lung diseases (ILDs), especially, systemic sclerosis-associated ILD. The results are evident that HRCT should be used as compared to the conventional chest X-rays. It is more precisely diagnosed (93.6) compared to standard X-rays (71.7) and odds ratio is almost 24 times greater. The various authors introduce and validate the Composite Interstitial Lung Disease Index (C-ILDI) which is a quantitative index (has weights) comprising the addition of the percentage of the ground-glass opacities (percentage of the GGO) and fibrotic (percentage of the FIB) involvement. This is the best composite index that was employed as a predictor of the disease progression (odds ratio of 1.096 increase in the index by one unit, $p < 0.001$) and mortality. The tertile with high risk (C-ILDI > 75) patients were found to be at a higher risk of death (14.3 times) at 24 months. The longitudinal outcome showed that the fibrotic load gradually worsens with time and at 12 months, there is a 19.8 percent increment of the fibrotic burden even though the ground-glass opacities have relative stability. This implies that once fibrosis has been established then it cannot be undone and it is hence quite important to work towards ensuring that it is avoided by all means. The comparison also revealed that the parameters of HRCT are highly correlated with the pulmonary functional tests, quantitatively. The forced vital capacity (r = -0.724) and the diffusing capacity (r = -0.691) are both good examples of this as they are both strongly negatively correlated with the percentageFIB. The high correlation between the software of the computer-aided diagnosis and the visual evaluation of the experts (Cohen, > 0.83 on all the features) suggests that it is possible to achieve the quantification

performed automatically and reproducibly in the typical clinical setting. Lastly, quantitative HRCT analysis of clinical operations facilitates the objective, reproducible and prognostically relevant measurement of ILD which in turn facilitates individualised treatment strategies and better patient outcomes through the paradigm shift to qualitative pattern identification to quantifiable disease phenotyping.

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