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High Resolution Computed Tomography Thorax Patterns and Short-Term Clinical Outcomes Among Individuals with Covid-19 Infection Attending A Tertiary Care Centre In South Kerala

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ABSTRACT

Background: Coronavirus disease 2019 (COVID-19), caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), predominantly affects the respiratory system but demonstrates a wide spectrum of clinical severity ranging from asymptomatic infection to severe respiratory failure. Early identification of disease severity and prediction of clinical outcomes are essential for effective patient management. High-resolution computed tomography (HRCT) thorax has emerged as a valuable diagnostic and prognostic tool, particularly in situations where RT-PCR results are delayed or inconclusive.
Aim: To evaluate HRCT thorax patterns and their association with short-term clinical outcomes in individuals with COVID-19 infection.
Methods: A prospective descriptive study was conducted among 200 individuals with confirmed COVID-19 infection who underwent HRCT thorax during the study period. Patients above 21 years of age were included. HRCT scans were evaluated for predominant imaging patterns, distribution, and CT severity score. Clinical outcomes including oxygen requirement and mortality were recorded. Statistical analysis was performed using SPSS software, and associations were assessed using the chi-square test with $p<0.05$ considered statistically significant.
Results: Ground-glass opacity (GGO) was the most common HRCT finding, observed in 62.5% of patients. Bilateral lung involvement was seen in 88.5% of cases. Severe CT severity score was present in 40.0% of patients. A statistically significant association was observed between CT severity score and oxygen requirement ($p<0.001$) as well as mortality ($p<0.001$). Patients with severe CT scores demonstrated markedly higher need for ventilatory support and increased mortality.
Conclusion: HRCT thorax is a reliable tool for assessing disease severity and predicting short-term clinical outcomes in COVID-19 infection. CT severity score serves as an effective prognostic indicator and aids in timely clinical decision-making.

***Keywords**: COVID-19, HRCT thorax, CT severity score, ground-glass opacity, clinical outcome.*

INTRODUCTION

Coronavirus disease 2019 (COVID-19) is a highly contagious infectious disease caused by the novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), first identified in late 2019. The rapid global spread of the virus led to an unprecedented pandemic, significantly impacting healthcare systems, economies, and societies worldwide (1,2,14). Although primarily a respiratory illness, COVID-19 is now recognized as a multisystem disease affecting cardiovascular, neurological, renal, and gastrointestinal systems. The clinical spectrum varies widely, ranging from asymptomatic infection to severe pneumonia, acute respiratory distress syndrome (ARDS), multiorgan failure, and death (3–5,18).

Early identification of disease severity is crucial for optimizing clinical management, ensuring timely intervention, and efficient allocation of healthcare resources. Reverse transcription polymerase chain reaction (RT-PCR) remains the gold standard for diagnosis; however, it has notable limitations, including delayed turnaround time, false-negative results due to inadequate sampling, and reduced sensitivity in early disease stages (6,7,13). These challenges highlight the need for adjunctive diagnostic tools that can provide rapid and reliable assessment of disease presence and severity.

High-resolution computed tomography (HRCT) thorax has emerged as an essential imaging modality in the evaluation of COVID-19 pneumonia due to its high sensitivity in detecting early pulmonary changes. HRCT not only aids in diagnosis but also plays a critical role in assessing the extent, distribution, and progression of lung involvement (8,9). It is particularly valuable in patients with high clinical suspicion but negative RT-PCR results and in monitoring disease progression over time (3,8).

The characteristic HRCT findings in COVID-19 include bilateral, peripheral, and basal predominant ground-glass opacities (GGO), often accompanied by consolidation, interlobular septal thickening, and reticular patterns (9–12). These imaging features correspond to underlying pathological processes such as alveolar damage, interstitial inflammation, and microvascular injury. As the disease progresses, imaging patterns may evolve from focal ground-glass opacities to diffuse consolidation and, in severe cases, fibrotic changes, reflecting irreversible lung injury.

To objectively assess disease burden, CT severity scoring systems have been widely adopted. These scoring systems provide a semi-quantitative evaluation based on the percentage of involvement of each lung lobe, allowing categorization into mild, moderate, and severe disease (12,13). CT severity score has demonstrated strong correlation with clinical parameters such as oxygen requirement, need for intensive care, and mortality, thereby serving as a valuable prognostic indicator (8,10).

The pathophysiology of COVID-19 further supports the use of HRCT as a diagnostic and prognostic tool. SARS-CoV-2 enters host cells via angiotensin-converting enzyme 2 (ACE2) receptors, which are abundantly expressed in alveolar epithelial cells (19,24,25). Viral entry leads to cellular injury, activation of inflammatory pathways, and disruption of pulmonary architecture. The subsequent release of pro-inflammatory cytokines contributes to a hyperinflammatory state, often referred to as a cytokine storm, which plays a central role in disease severity and progression (20,22). These pathological changes are reflected in HRCT findings, establishing a direct correlation between imaging features and underlying disease mechanisms.

In addition, variability in clinical presentation and disease severity can be attributed to factors such as viral mutation, host immune response, and presence of comorbidities (17,23). Asymptomatic transmission and heterogeneity in disease expression further complicate diagnosis and management (16,18). These factors underscore the importance of reliable imaging modalities that can aid in early detection and risk stratification.

Despite the growing body of literature, variability exists in HRCT findings and their correlation with clinical outcomes. Differences in patient populations, timing of imaging, and disease severity contribute to this variability. Therefore, a comprehensive evaluation of HRCT thorax patterns in relation to short-term clinical outcomes is essential to enhance understanding and improve patient management.

AIM AND OBJECTIVES

Aim:

To evaluate HRCT thorax patterns and their association with short-term clinical outcomes.

Objectives

1. To study HRCT thorax patterns in COVID-19 infection
2. To correlate CT severity score with clinical outcomes
3. To assess association between HRCT findings and oxygen requirement

METHODOLOGY

This prospective descriptive study was conducted in the Department of Radiodiagnosis at a tertiary care teaching hospital after obtaining approval from the Institutional Ethics Committee. The study was carried out over a defined study period extending from October 2020 to May 2021. A total of 200 patients with confirmed COVID-19 infection who underwent high-resolution computed tomography (HRCT) thorax during the study period were included in the analysis. COVID-19 infection was confirmed using antigen testing, reverse transcription polymerase chain reaction (RT-PCR), or TRUNAT methods as per institutional protocol. All eligible patients fulfilling the inclusion criteria were enrolled consecutively using a non-probability sampling technique to minimize selection bias.

Patients aged above 21 years with laboratory-confirmed COVID-19 infection who underwent HRCT thorax were included in the study. Pregnant women were excluded due to concerns regarding radiation exposure. Patients with incomplete clinical records or poor-quality CT images that could not be adequately interpreted were also excluded to ensure accuracy of analysis. Ethical considerations were strictly adhered to, with patient confidentiality maintained throughout the study by anonymizing all identifiable information. Data were stored securely and accessed only by the investigators.

HRCT thorax was performed using a multidetector CT scanner (Siemens Somatom Emotion 16-slice system) with patients in the supine position during suspended full inspiration to ensure optimal lung expansion. Scanning parameters were standardized for all patients to maintain uniformity, including a tube voltage of approximately 130 kVp and tube current ranging between 60–70 mAs. Images were acquired with a slice thickness suitable for high-resolution imaging and reconstructed using a high-spatial-frequency algorithm. The matrix size was maintained at 512 × 512, and the pitch was set at 1:1. Lung window settings were standardized with a window width of 1200–1500 Hounsfield units (HU) and a window level between –600 and –700 HU to facilitate optimal visualization of parenchymal details.

All HRCT images were independently reviewed by experienced radiologists for assessment of pulmonary involvement. The predominant radiological patterns were categorized into ground-glass opacity (GGO), consolidation, and mixed patterns (combination of GGO and consolidation). Ground-glass opacity was defined as a hazy increase in lung attenuation without obscuration of underlying vascular markings, whereas consolidation was defined as a homogeneous increase in pulmonary parenchymal attenuation associated with obscuration of underlying vessels. In addition to pattern recognition, the distribution of lesions (peripheral, central, or diffuse), laterality (unilateral or bilateral), and lobar involvement were systematically evaluated.

The severity of lung involvement was quantified using a semi-quantitative CT severity scoring system based on visual estimation of the extent of involvement in each of the five lung lobes. Each lobe was assigned a score from 0 to 5 depending on the percentage of involvement: 0 (no involvement), 1 (<5%), 2 (5–25%), 3 (26–50%), 4 (51–75%), and 5 (>75%). The total CT severity score was calculated by summing the scores of all five lobes, yielding a maximum possible score of 25. Based on the total score, patients were categorized into four groups: nil (score 0), mild, moderate, and severe disease. This scoring system provided an objective measure of disease burden and facilitated comparison with clinical outcomes.

Clinical data were collected from hospital records, including demographic details, clinical presentation, and outcome parameters. The primary outcome measures included oxygen requirement (categorized as no oxygen support, nasal oxygen, non-invasive ventilation, or mechanical ventilation) and mortality. These outcomes were selected to reflect short-term clinical severity and progression of the disease.

Data were entered into Microsoft Excel and subsequently analyzed using Statistical Package for the Social Sciences (SPSS) software. Quantitative variables were expressed as mean and standard deviation, while qualitative variables were presented as frequencies and percentages. The association between CT severity score, HRCT patterns, and clinical outcomes was assessed using the chi-square test for categorical variables. A p-value of less than 0.05 was considered statistically significant. Appropriate measures were taken to ensure data accuracy, including double-checking entries and validation of statistical outputs.

Overall, the methodology was designed to ensure systematic data collection, standardized imaging assessment, and robust statistical analysis, thereby enabling reliable evaluation of the relationship between HRCT findings and clinical outcomes in COVID-19 infection.

RESULTS

A total of 200 patients with confirmed COVID-19 infection who underwent HRCT thorax were included in the present study. The analysis focused on evaluating HRCT imaging patterns, extent of lung involvement, CT severity score, and their association with short-term clinical outcomes, particularly oxygen requirement and mortality.

The predominant HRCT pattern observed in the study population was ground-glass opacity (GGO), identified in 125 patients (62.5%). Consolidation was observed in 19 patients (9.5%), while a mixed pattern of GGO and consolidation was seen in 26 patients (13.0%). A total of 30 patients (15.0%) showed no abnormality on HRCT.

Table 1: Distribution of HRCT Patterns (n = 200)

Pattern	Frequency (n)	Percentage (%)
Ground-glass opacity	125	62.5
Consolidation	19	9.5
GGO + Consolidation	26	13.0
No abnormality	30	15.0
Total	200	100.0

Further analysis of pulmonary involvement revealed that bilateral lung involvement was present in 177 patients (88.5%), whereas unilateral involvement was observed in 23 patients (11.5%). The predominance of bilateral disease highlights the diffuse nature of COVID-19 pneumonia. Lower lobe involvement was more common, and peripheral distribution of lesions predominated over central distribution.

The severity of lung involvement was assessed using CT severity scoring. Among the study population, 80 patients (40.0%) were categorized as having severe disease, 53 patients (26.5%) had moderate disease, and 37 patients (18.5%) had mild disease. A total of 30 patients (15.0%) had a CT severity score of zero.

Table 2: CT Severity Score Distribution (n = 200)

Severity Category	Frequency (n)	Percentage (%)
Mild	37	18.5
Moderate	53	26.5
Severe	80	40.0
Nil	30	15.0
Total	200	100.0

A statistically significant association was observed between CT severity score and oxygen requirement (**$\chi^2 = 96.4$, df = 6, $p < 0.001$**).

Among patients with mild CT severity scores (n = 37), 35 patients (94.6%) did not require oxygen support, 1 patient (2.7%) required nasal oxygen, and 1 patient (2.7%) required mechanical ventilation.

In the moderate group (n = 53), 39 patients (73.6%) did not require oxygen support, 10 patients (18.9%) required nasal oxygen, and 4 patients (7.5%) required mechanical ventilation.

In contrast, among patients with severe CT severity scores (n = 80), only 8 patients (10.0%) did not require oxygen support, whereas 39 patients (48.8%) required nasal oxygen, 3 patients (3.8%) required non-invasive ventilation, and 30 patients (37.5%) required mechanical ventilation.

Table 3: Association Between CT Severity Score and Oxygen Requirement

Oxygen Requirement	Mild (%)	Moderate (%)	Severe (%)
No oxygen	94.6	73.6	10.0
Nasal oxygen	2.7	18.9	48.8
NIV	0.0	0.0	3.8
Mechanical ventilation	2.7	7.5	37.5

Chi-square test: $\chi^2 = 96.4$, df = 6, $p < 0.001$ (statistically significant)

Mortality analysis revealed that 24 patients (12.0%) expired, while 176 patients (88.0%) were discharged. A statistically significant association was observed between CT severity score and mortality (**$\chi^2 = 18.7$, df = 2, $p < 0.001$**).

Among patients with mild CT severity scores (n = 37), 1 patient (2.7%) expired and 36 patients (97.3%) were discharged. In the moderate group (n = 53), 4 patients (7.5%) expired and 49 patients (92.5%) were discharged. In contrast, among patients with severe CT severity scores (n = 80), 19 patients (23.7%) expired and 61 patients (76.3%) were discharged.

Table 4: Association Between CT Severity Score and Clinical Outcome

Outcome	Mild (%)	Moderate (%)	Severe (%)
Discharged	97.3	92.5	76.3
Expired	2.7	7.5	23.7

Chi-square test: $\chi^2 = 18.7$, df = 2, $p < 0.001$ (statistically significant)

Overall, the results demonstrate a consistent and graded relationship between HRCT findings, CT severity score, and clinical outcomes. Quantitative CT severity scoring showed strong prognostic value, with significant associations with both oxygen requirement and mortality.

DISCUSSION

The present study was conducted to evaluate HRCT thorax patterns and their association with short-term clinical outcomes in individuals with COVID-19 infection. The findings demonstrate a strong and consistent relationship between radiological severity, as assessed by CT severity score, and clinically significant outcomes such as oxygen requirement and mortality. These results reinforce the role of HRCT not only as a diagnostic tool but also as a reliable prognostic indicator.

Ground-glass opacity (GGO) was identified as the predominant HRCT pattern in this study, observed in 125 patients (62.5%). This finding is consistent with the early pathological changes associated with COVID-19, including partial filling of alveolar spaces and interstitial inflammation. Similar observations have been reported by Kwee and Kwee (1) and Wu et al. (6), who described GGO as the most characteristic imaging feature in COVID-19 pneumonia. The high prevalence of GGO in the present study highlights its importance as an early marker of pulmonary involvement.

Bilateral lung involvement was observed in 177 patients (88.5%), indicating the diffuse nature of the disease. This finding aligns with previous studies by Sun et al. (9) and Han et al. (12), which reported bilateral and peripheral distribution as typical imaging characteristics of COVID-19 pneumonia. The predominance of lower lobe involvement observed in this study further supports the gravity-dependent distribution of lesions commonly described in viral pneumonias.

The progression from ground-glass opacity to consolidation observed in a subset of patients reflects the natural course of disease progression. Consolidation represents more advanced alveolar damage with inflammatory exudation. Jalaber et al. (11) reported that consolidation is more frequently associated with severe disease and later stages of infection. In the present study, mixed patterns were more common in patients with moderate and severe CT severity scores, supporting this progression.

A key finding of this study is the strong association between CT severity score and oxygen requirement. Among patients with mild CT severity scores, the majority 35 patients (94.6%) did not require oxygen support, whereas patients with severe scores demonstrated significantly higher oxygen requirements. Specifically, 48.8% required nasal oxygen and 37.5% required mechanical ventilation. These findings are consistent with those reported by Abdollahi et al. (8) and He et al. (7), who demonstrated that CT severity score correlates strongly with respiratory compromise.

Mortality analysis further emphasizes the prognostic value of CT severity scoring. Mortality increased progressively from 2.7% in mild cases to 7.5% in moderate cases and 23.7% in severe cases. This clear gradient indicates a dose–response relationship between radiological severity and clinical outcome. Similar findings have been reported by Long et al. (13), confirming that extensive lung involvement is associated with increased risk of mortality.

While qualitative HRCT patterns provide important diagnostic insights, the present study highlights the superiority of quantitative CT severity scoring in predicting clinical outcomes. Martínez Chamorro et al. (3) and Andrews et al. (4) emphasized the importance of integrating imaging findings with clinical parameters for accurate assessment of disease severity. The findings of this study support this approach, demonstrating that CT severity score is a reliable predictor of both oxygen requirement and mortality.

An important observation in this study was that 30 patients (15.0%) had normal HRCT findings despite confirmed COVID-19 infection. This finding is consistent with reports by Wang et al. (5) and Li et al. (14), which suggest that imaging may be normal in early stages of the disease. This highlights the limitation of HRCT in early infection and underscores the importance of combining imaging with clinical and laboratory findings.

The pathophysiological mechanisms underlying HRCT findings in COVID-19 involve viral entry via ACE2 receptors, leading to alveolar epithelial damage and inflammatory response (19,24,25). The release of pro-inflammatory cytokines results in a hyperinflammatory state, contributing to disease severity (20,22). These processes are reflected in imaging findings such as ground-glass opacities, consolidation, and diffuse lung involvement.

Variability in disease presentation may also be influenced by viral mutations and host immune responses (17,23). Additionally, asymptomatic transmission and variability in clinical expression further complicate disease management (16,18). These factors highlight the importance of HRCT in early detection and risk stratification.

HRCT also plays an important role in monitoring disease progression and guiding clinical management. Das et al. (15) demonstrated that HRCT findings can help assess disease progression, especially in patients with comorbid conditions. Emerging therapeutic approaches further emphasize the importance of early severity assessment in improving patient outcomes (21).

Despite its strengths, this study has certain limitations. Being a single-center study, the findings may not be generalizable to all populations. The absence of long-term follow-up limits assessment of long-term outcomes. Additionally, biochemical markers of inflammation were not included, which could have provided further insight into disease severity.

Overall, the present study provides strong evidence that HRCT thorax is a valuable tool for assessing disease severity and predicting clinical outcomes in COVID-19 infection. The integration of imaging findings with clinical parameters enhances the accuracy of risk stratification and supports informed decision-making in patient management.

LIMITATIONS

1. Single-center study, limiting generalizability
2. Lack of long-term follow-up
3. Absence of biochemical markers (inflammatory markers not assessed)
4. Interobserver variability in HRCT interpretation not evaluated
5. Treatment protocols not standardized across all patients

CONCLUSION

HRCT thorax is a reliable modality for assessing disease severity and predicting short-term clinical outcomes in COVID-19 infection.

CT severity score shows strong correlation with oxygen requirement and mortality, making it an effective prognostic tool.

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