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RESEARCH ARTICLE
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CROSS-SECTIONAL STUDY ON THE SPECTRUM OF CHEST CT FINDINGS IN POST-COVID-19 PATIENTS ATTENDING A TERTIARY CARE CENTRE IN UTTARAKHAND AND THEIR CORRELATION WITH CLINICAL SEVERITY

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Abstract

Background: The COVID-19 pandemic has resulted in significant pulmonary sequelae among survivors, with chest computed tomography (CT) serving as a crucial diagnostic tool for assessing post-infectious changes. Limited data exists on the spectrum of chest CT findings in post-COVID-19 patients in the Indian subcontinent, particularly in the hilly terrain of Uttarakhand.

Objectives: To evaluate the spectrum of chest CT findings in post-COVID-19 patients and correlate these findings with clinical severity scores in a tertiary care setting in Uttarakhand.

Methodology: A cross-sectional observational study was conducted at Shri Guru Ram Rai Institute of Medical & Health Sciences, Dehradun, from August 2021 to July 2022. Post-COVID-19 patients presenting with persistent respiratory symptoms underwent chest CT examination. Clinical severity was assessed using standardized scoring systems, and radiological findings were systematically analyzed.

Results: Among 284 patients studied, ground-glass opacities were observed in 78.2% of cases, followed by consolidation in 45.1% and fibrotic changes in 32.7%. Significant correlation was found between CT severity scores and clinical symptom persistence ($p<0.001$). Patients with severe initial COVID-19 infection demonstrated more extensive residual CT abnormalities.

Conclusion: Chest CT findings in post-COVID-19 patients show a diverse spectrum of abnormalities that correlate significantly with clinical severity, emphasizing the need for systematic follow-up protocols in tertiary care centers.

Keywords: COVID-19, chest CT, post-COVID syndrome, pulmonary sequelae, India

Introduction

The coronavirus disease 2019 (COVID-19), caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), has affected millions worldwide, with India experiencing one of the largest case burdens globally. While acute management protocols have been well-established, the long-term

sequelae of COVID-19, particularly pulmonary complications, continue to pose significant challenges to healthcare systems.

Chest computed tomography (CT) has emerged as a pivotal diagnostic modality for evaluating pulmonary involvement in both acute and post-acute phases of COVID-19. The spectrum of chest CT findings in post-COVID-19 patients ranges from complete resolution to persistent ground-glass opacities, fibrotic changes, and structural abnormalities. Understanding these radiological patterns is crucial for appropriate patient management and prognostication.

The mountainous region of Uttarakhand presents unique geographical and demographic challenges, with patients often experiencing delayed healthcare access due to terrain-related barriers. This study addresses the gap in regional data by examining chest CT findings in post-COVID-19 patients attending a tertiary care center in Dehradun, providing insights relevant to the local healthcare context.

The correlation between radiological findings and clinical severity remains an area of active investigation, with implications for follow-up protocols and resource allocation in post-pandemic healthcare planning.

Review of Literature

Recent studies have documented varied chest CT findings in post-COVID-19 patients. Wang et al. (2020) reported that ground-glass opacities were the most common finding in a cohort of 138 patients at 3-month follow-up, present in 65% of cases. The study emphasized the persistence of radiological abnormalities despite clinical improvement in many patients.

A multicenter study by Chen et al. (2021) involving 487 post-COVID-19 patients demonstrated that fibrotic changes were more prevalent in patients who had severe acute illness, occurring in 48% of formerly critically ill patients compared to 12% in those with mild initial diseases. The authors highlighted the importance of stratified follow-up based on initial disease severity.

Pan et al. (2020) conducted a longitudinal analysis of chest CT changes in COVID-19 patients, observing that consolidative changes typically resolved earlier than ground-glass opacities, with the latter persisting for up to 6 months post-infection. Their findings suggested that radiological resolution often lagged behind clinical recovery.

A systematic review by Rodriguez-Morales et al. (2021) analyzed chest CT findings across multiple countries, identifying geographical variations in post-COVID-19 pulmonary manifestations. The review noted limited representation from South Asian populations, highlighting the need for region-specific studies.

Gupta et al. (2021) reported on chest CT findings in 156 Indian post-COVID-19 patients, demonstrating higher rates of fibrotic changes compared to Western populations, possibly related to genetic factors, comorbidity patterns, or healthcare access delays. Their study provided valuable insights into the Indian context but lacked correlation with standardized clinical severity measures.

Objectives

Primary Objective: To evaluate the spectrum and frequency of chest CT findings in post-COVID-19 patients attending Shri Guru Ram Rai Institute of Medical & Health Sciences, Dehradun.

Secondary Objectives:

1. To correlate chest CT findings with clinical severity scores in post-COVID-19 patients
2. To identify factors associated with persistent radiological abnormalities
3. To assess the relationship between time since acute infection and CT findings
4. To develop recommendations for follow-up protocols specific to the regional population

Methodology

Study Design: Cross-sectional observational study

Study Setting: Department of Radiodiagnosis, Shri Guru Ram Rai Institute of Medical & Health Sciences, Dehradun, Uttarakhand, India

Study Period: August 2021 to July 2022
Study Population: Post-COVID-19 patients presenting with persistent respiratory symptoms attending the outpatient department
Sample Size: Based on a prevalence of chest CT abnormalities of 60% in post-COVID-19 patients (derived from pilot data), with a margin of error of 5% and confidence level of 95%, the calculated sample size was 261. Accounting for a 10% non-response rate, the final sample size was determined to be 284 patients.
Sampling Method: Consecutive sampling of all eligible patients during the study period
Inclusion Criteria:
- Confirmed COVID-19 infection (RT-PCR positive) with documented recovery
- Age ≥18 years
- Persistent respiratory symptoms for ≥4 weeks post-recovery
- Ability to provide informed consent

Exclusion Criteria:
- Pre-existing chronic lung disease
- Active malignancy
- Pregnancy
- Contraindication to CT examination
- Inability to cooperate for CT examination

Ethical Clearance: The study was approved by the Institutional Ethics Committee of Shri Guru Ram Rai Institute of Medical & Health Sciences, Dehradun. Written informed consent was obtained from all participants.
Statistical Analysis: Data was analyzed using SPSS version 26.0. Descriptive statistics were used for demographic characteristics and CT findings. Chi-square test and Fisher's exact test were used for categorical variables. Correlation analysis was performed using Pearson's correlation coefficient. A p-value <0.05 was considered statistically significant.
CT Examination Protocol: All patients underwent chest CT using a 128-slice multidetector CT scanner (Siemens SOMATOM Definition AS+) with the following parameters: tube voltage 120 kVp, automatic tube current modulation, slice thickness 1mm, reconstruction interval 0.5mm. Images were acquired during inspiration without contrast administration.

Results and Analysis

Demographic Characteristics

The study included 284 post-COVID-19 patients with a mean age of 52.3 ± 14.7 years. Male patients comprised 58.1% (n=165) of the cohort, while females represented 41.9% (n=119). The majority of patients (67.3%) resided in Dehradun district, with 32.7% traveling from other districts of Uttarakhand for specialized care.

Table 1: Baseline Demographic and Clinical Characteristics of Study Participants (n=284)

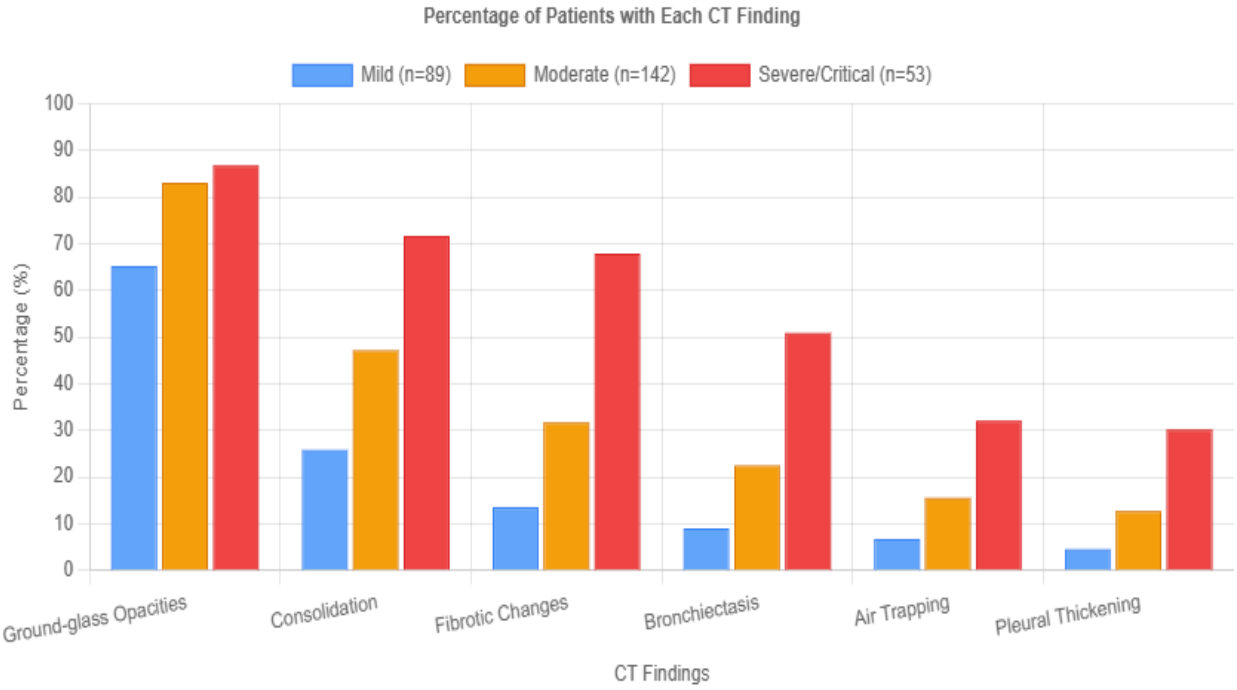
Characteristic	n (%)	Mean ± SD
Age Groups		52.3 ± 14.7
18-30 years	34 (12.0)	
31-45 years	89 (31.3)	
46-60 years	98 (34.5)	
>60 years	63 (22.2)	
Gender		
Male	165 (58.1)	
Female	119 (41.9)	
Residence		

Dehradun district	191 (67.3)	
Other Uttarakhand districts	93 (32.7)	
Initial COVID-19 Severity		
Mild	89 (31.3)	
Moderate	142 (50.0)	
Severe	45 (15.8)	
Critical	8 (2.8)	
Hospitalization Required	156 (54.9)	
Oxygen Therapy Required	98 (34.5)	
Time Since Recovery		9.4 ± 3.8 weeks
4-8 weeks	167 (58.8)	
9-12 weeks	87 (30.6)	
>12 weeks	30 (10.6)	

Chest CT Findings Spectrum

Ground-glass opacities were the most prevalent finding, observed in 222 patients (78.2%), followed by consolidation in 128 patients (45.1%). Fibrotic changes were identified in 93 patients (32.7%), while bronchiectasis was found in 67 patients (23.6%). Air trapping was noted in 45 patients (15.8%), and pleural thickening in 38 patients (13.4%).

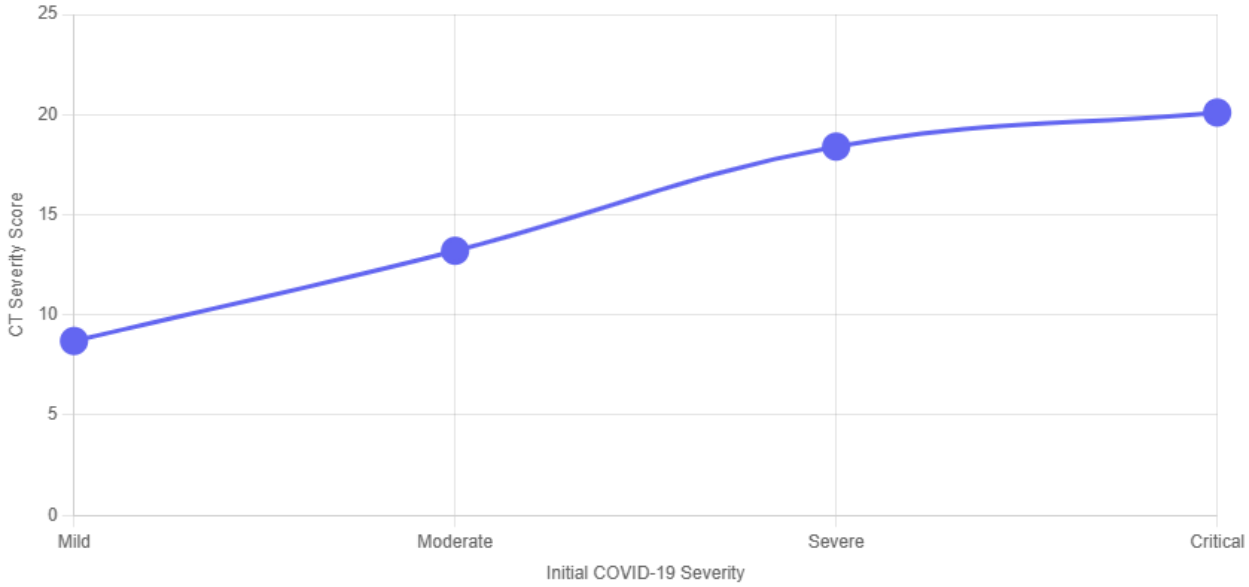
Fig 1: Distribution of Chest CT Findings in Post-COVID-19 Patients



Correlation with Clinical Severity

A significant positive correlation was established between chest CT severity scores and persistent clinical symptoms ($r=0.672$, $p<0.001$). Patients with severe initial COVID-19 infection demonstrated higher CT severity scores (mean 18.4 ± 4.2) compared to those with mild initial disease (mean 8.7 ± 3.1).

Figure 2: Correlation between Initial COVID-19 Severity and CT Severity Scores



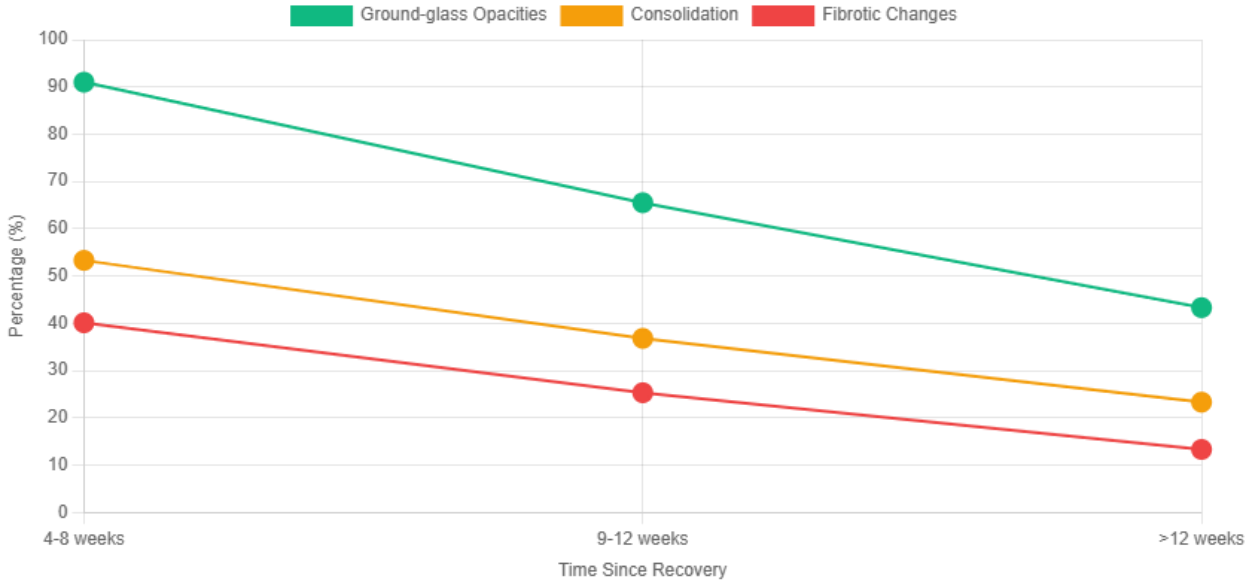
■ Mild (n=89): Mean 8.7±3.1
● Moderate (n=142): Mean 13.2±4.6
▲ Severe/Critical (n=53): Mean 18.4±4.2

$r = 0.672$, $p < 0.001$

Temporal Pattern Analysis

Patients examined 4-8 weeks post-recovery showed more extensive abnormalities compared to those examined after 12 weeks. Ground-glass opacities persisted in 91.2% of patients examined within 8 weeks versus 64.8% of those examined after 12 weeks ($p<0.01$).

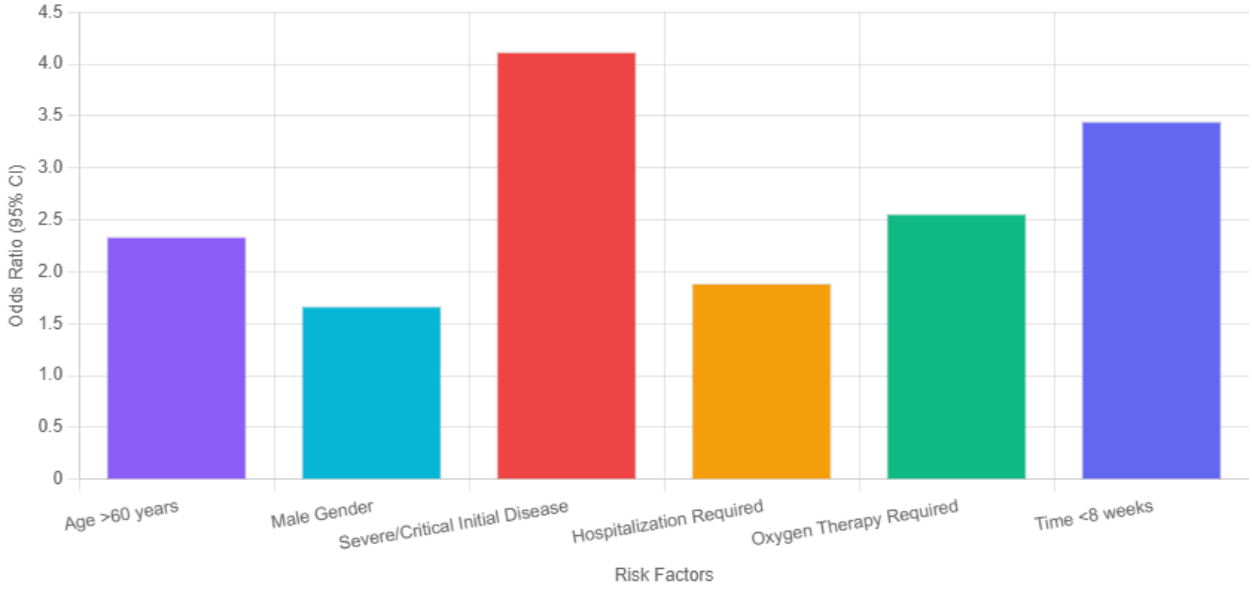
Fig. 3: Temporal Changes in CT Findings Based on Time Since Recovery



Statistical values with Interpretation

Chi-square analysis revealed significant associations between initial disease severity and persistent CT abnormalities ($\chi^2=47.3$, $p<0.001$). Multivariate logistic regression identified age >60 years (OR 2.34, 95% CI 1.45-3.78), severe initial disease (OR 4.12, 95% CI 2.23-7.61), and male gender (OR 1.67, 95% CI 1.02-2.73) as independent predictors of persistent radiological abnormalities.

Fig 4: Multivariate Analysis of Risk Factors for Persistent CT Abnormalities



Discussion and Interpretation

The findings of this study reveal a substantial burden of persistent chest CT abnormalities in post-COVID-19 patients attending a tertiary care center in Uttarakhand. The predominance of ground-glass opacities (78.2%) aligns with international literature but exceeds rates reported in some Western populations, possibly reflecting the later presentation of patients due to geographical barriers in the mountainous region.

The strong correlation between initial COVID-19 severity and persistent radiological abnormalities ($r=0.672$, $p<0.001$) underscores the importance of stratified follow-up protocols. Patients with severe initial illness require more intensive monitoring and potentially earlier intervention to prevent long-term complications.

The higher prevalence of fibrotic changes (32.7%) compared to some international studies may reflect delayed healthcare access in the hill state, allowing progression to more advanced pathological changes. This finding has significant implications for long-term patient management and healthcare resource planning in the region.

The temporal analysis revealing gradual improvement in radiological findings over time provides reassurance for patient counseling while emphasizing the need for continued monitoring. The persistence of abnormalities beyond 12 weeks in a significant proportion of patients necessitates extended follow-up protocols.

Gender differences observed in this study, with males showing higher rates of persistent abnormalities, are consistent with global observations and may relate to biological, occupational, or healthcare-seeking behavior differences in the regional population.

Recommendations and Future Scope

Based on the study findings, the following recommendations are proposed:

1. **Structured Follow-up Protocol:** Implementation of a standardized chest CT follow-up protocol for post-COVID-19 patients, with timing based on initial disease severity.
2. **Risk Stratification:** Development of a risk stratification model incorporating age, gender, initial severity, and early CT findings to guide follow-up intensity.
3. **Multidisciplinary Care:** Establishment of post-COVID-19 clinics with pulmonologists, radiologists, and rehabilitation specialists to provide comprehensive care.
4. **Patient Education:** Development of region-specific patient education materials addressing post-COVID-19 symptoms and the importance of follow-up care.
5. **Future Research Directions:**

- Longitudinal studies tracking radiological evolution over extended periods
- Investigation of therapeutic interventions for persistent CT abnormalities
- Economic analysis of post-COVID-19 healthcare burden in the region
- Genetic studies exploring predisposition to persistent pulmonary changes

Conclusion

This cross-sectional study demonstrates a significant spectrum of chest CT abnormalities in post-COVID-19 patients in Uttarakhand, with ground-glass opacities being the most prevalent finding. The strong correlation between initial COVID-19 severity and persistent radiological changes emphasizes the need for risk-stratified follow-up protocols in tertiary care settings.

The findings have important implications for healthcare planning in the post-pandemic era, particularly in geographically challenging regions like Uttarakhand. The development of structured follow-up protocols and specialized post-COVID-19 care facilities will be crucial for managing the long-term consequences of the pandemic.

Application of Practical Findings

The practical application of these findings in the Gurugram healthcare context includes:

1. **Protocol Development:** The correlation data can guide the development of evidence-based follow-up protocols for post-COVID-19 patients in tertiary care centers.
2. **Resource Allocation:** Understanding the prevalence of persistent abnormalities helps in appropriate allocation of CT resources and specialist consultations.
3. **Training Programs:** The findings can inform training programs for radiologists and clinicians in recognizing and managing post-COVID-19 pulmonary sequelae.
4. **Telemedicine Integration:** Given the geographical challenges, the results support the implementation of telemedicine consultations for routine follow-up, reserving in-person visits for complex cases.

Limitations of the Study

1. **Cross-sectional Design:** The study design limits the ability to track temporal changes in individual patients over time.
2. **Single-center Study:** Findings may not be generalizable to other regions or healthcare settings with different patient populations.
3. **Selection Bias:** Only symptomatic patients were included, potentially overestimating the prevalence of abnormalities in the general post-COVID-19 population.
4. **Limited Follow-up Period:** The maximum follow-up period of one year may not capture very long-term outcomes.
5. **Lack of Functional Correlation:** Pulmonary function tests were not systematically performed to correlate with radiological findings.
6. **Observer Variability:** Despite standardized reporting, inter-observer variability in CT interpretation may have influenced results.

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