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Original Article

Evaluating Respiratory Recovery: Spirometry And HRCT Findings In Post-Acute Covid-19 Subjects

Dr Javied Malik[1], Mohd Irfan Ali Khan[2], Dr Javed Khan[3*]

[1]Senior Resident, Department of Respiratory Medicine, Varun Arun Medical College & Rohilkhand Hospital

[2]Associate Professor, Department of Respiratory Medicine, Varun Arun Medical College & Rohilkhand Hospital

[3*]Associate Professor, Department of Respiratory Medicine, Rohilkhand Medical College & Rohilkhand Hospital

***Corresponding Author:** Dr Javed Khan

Email Id: javedpulmonarymedicine@gmail.com

Abstract

Background: The COVID-19 pandemic, caused by the SARS-CoV-2 virus, has led to significant global health challenges. While the acute respiratory effects of COVID-19 are well-documented, there is a growing need to understand the post-acute sequelae of the disease, particularly regarding respiratory function and radiological changes in recovered subjects.

Methods: This longitudinal cohort study, conducted from March to September 2021, included 50 post-COVID-19 subjects from Rohilkhand Medical College and Hospital, India. The study evaluated respiratory functions and radiological changes at the 4th and 8th week follow-ups post-recovery. Pulmonary Function Tests (PFTs) and High-Resolution Computed Tomography (HRCT) scans were utilized for assessment.

Results: The study population predominantly consisted of males (66%), with a significant proportion of smokers (26%). Disease severity was categorized as mild (28%), moderate (20%), and severe (52%). Spirometry findings in the 4th week showed normal lung function in all mild cases but revealed a restrictive pattern in 40% of moderate and severe cases. By the 8th week, 75% of moderate cases showed normal function. DLCO assessment indicated that a majority (84.62%) had below-normal values. HRCT findings in the 8th week demonstrated complete resolution in 10 subjects, while others showed persistent radiological abnormalities.

Conclusion: The study highlights the prolonged impact of COVID-19 on lung function, with many subjects exhibiting restrictive patterns in spirometry and abnormalities in HRCT scans weeks after recovery. These findings underscore the necessity for ongoing monitoring and tailored management strategies for post-COVID-19 subjects, especially those with severe initial presentations. The study's limitations include its small sample size and the absence of long-term follow-up data, suggesting the need for further research in this area.

Keywords: COVID-19, SARS-CoV-2, post-acute sequelae, pulmonary function, spirometry, HRCT, long-term effects.

Introduction

The novel coronavirus (COVID-19) outbreak in late 2019 rapidly escalated into a global pandemic, profoundly impacting public health systems worldwide. As the pandemic progressed, it became

evident that COVID-19, caused by the SARS-CoV-2 virus, was not only a transient respiratory illness but also had the potential to cause long-term health consequences. This realization necessitated a deeper understanding of the post-acute sequelae of COVID-19, particularly concerning respiratory functions and radiological changes in recovered subjects.

The acute phase of COVID-19 has been extensively studied and documented, revealing a spectrum of respiratory manifestations ranging from mild flu-like symptoms to severe pneumonia and acute respiratory distress syndrome (ARDS) [1]. However, as the pandemic evolved, it became increasingly clear that even subjects who had recovered from the acute phase continued to experience various symptoms, including persistent respiratory difficulties [2]. This phenomenon has raised concerns about the long-term pulmonary impacts of COVID-19, necessitating further research into post-COVID-19 respiratory function.

Recent studies have begun to shed light on the post-acute phase of COVID-19, often referred to as "long COVID" or "post-acute sequelae of SARS-CoV-2 infection (PASC)." These studies have documented various persistent symptoms and complications, including respiratory symptoms, fatigue, and cognitive disturbances [3]. However, there remains a significant gap in our understanding of the specific respiratory and radiological changes in post-COVID-19 subjects, particularly with the severity of the initial illness.

Pulmonary Function Tests (PFTs) are well-established in respiratory medicine for assessing respiratory impairment. PFTs provide valuable information on lung volume, capacity, flow rates, and gas exchange, which are crucial for diagnosing and monitoring various pulmonary conditions [4]. In COVID-19, PFTs can be vital in evaluating the extent of pulmonary damage and recovery in post-COVID-19 subjects.

Radiological assessment, mainly through chest imaging techniques such as X-rays and computed tomography (CT) scans, has been instrumental in diagnosing and managing COVID-19 pneumonia [5]. These imaging modalities have revealed characteristics associated with COVID-19, such as ground-glass opacities and interlobular septal thickening. However, the persistence and evolution of these radiological findings in the post-COVID-19 phase remain to be comprehensively explored.

Given the ongoing impact of the COVID-19 pandemic and the emerging evidence of long-term respiratory complications, there is a pressing need to systematically investigate the respiratory functions and radiological changes in subjects who have recovered from COVID-19. This study addresses this gap by evaluating the respiratory functions and radiological changes in post-COVID-19 subjects at 4th and 8th week follow-ups. This study aims to provide a deeper understanding of the long-term pulmonary impacts of COVID-19, which is crucial for developing management strategies and guiding patient care in the post-acute phase of the disease.

Materials and Methods

Study Design and Participants

This study was designed as a longitudinal cohort study conducted from March 2021 to September 2021 at Rohilkhand Medical College and Hospital, India. It included a cohort of 50 post-COVID-19 subjects who had recovered from COVID-19. The severity of the initial COVID-19 infection among these subjects varied, ranging from mild to severe cases.

Inclusion Criteria:

1. Age: Participants aged 18 years and older.
2. Diagnosis: Confirmed diagnosis of COVID-19 through RT-PCR test.
3. Recovery Phase: Subjects in the post-acute phase of COVID-19, defined as being at least 4 weeks from the onset of initial symptoms or from the date of the positive COVID-19 test.
4. Symptomatology: Subjects who have experienced respiratory symptoms during the acute phase of COVID-19, such as cough, shortness of breath, or pneumonia.
5. Consent: Willingness and ability to provide informed consent for participation in the study.

6. Follow-up Availability: Ability to attend follow-up appointments for Pulmonary Function Tests (PFTs) and radiological assessments at specified intervals.

Exclusion Criteria:

1. Age: Individuals under the age of 18.
2. Severe Comorbid Conditions: Subjects with pre-existing severe respiratory diseases (e.g., advanced COPD, cystic fibrosis) or other critical illnesses that could confound the assessment of post-COVID-19 respiratory function.
3. Pregnancy: Pregnant women, due to potential risks associated with radiological assessments.
4. Recent Surgery: Subjects who have undergone major surgery within the last 8 weeks, which could affect respiratory function.
5. Inability to Perform PFTs: Subjects who are physically unable to perform Pulmonary Function Tests, such as those with severe neuromuscular disorders.
6. Non-consent: Individuals who are unable or unwilling to provide informed consent or adhere to the study protocol.
7. Other Infectious Diseases: Subjects with active tuberculosis or other infectious respiratory diseases at the assessment time.
8. Mental Incapacity: Individuals with cognitive impairments or psychiatric conditions that would limit their ability to understand the nature of the study and provide informed consent.

Procedures and Assessments

Participants underwent a comprehensive clinical evaluation, which included Pulmonary Function Tests (PFTs) and radiological assessments. These evaluations were conducted at two-time points: the 4th week and the 8th week post-recovery. The PFTs were performed using standard spirometry techniques to assess various lung function parameters, including forced vital capacity (FVC) and expiratory volume in one second (FEV1)—the radiological assessment involved chest imaging, primarily identifying ground glass opacities and interlobular septal thickening.

Equipment and Materials

The spirometry tests were conducted using a calibrated spirometer named MiniSpir, MIR, Italy. Radiological assessments were performed using GE Brightspeed 16 Slice (GE Healthcare, USA) a high-resolution computed tomography (HRCT). All drugs and chemicals used in the study were of analytical grade.

Statistical Methods

Data were analyzed using SPSS version 25 (IBM, USA). The variation in data was expressed in terms of the standard deviation (SD). The number of observations (n) for each parameter was also reported. Statistical significance was assessed using appropriate tests (e.g., t-test, ANOVA) with a predefined level of significance set at $p < 0.05$. The specific tests used for each parameter and group comparison were indicated.

Ethical Considerations

The Institutional Ethical Committee at Rohilkhand Medical College & Hospital reviewed and approved the study protocol. Informed consent was obtained from all participants before being included in the study. The study was conducted following the ethical standards of the Declaration of Helsinki.

Data Collection Procedure

Data were collected through direct assessments during the follow-up visits. For PFTs, participants were instructed on the procedure and performed the tests under the supervision of trained medical personnel. Radiological images were reviewed and interpreted by experienced radiologists.

Results

1. Patient Demographics and Clinical Presentation:

Demographic/Characteristic	Count (Percentage)
Total Subjects	50.0 (100)
Gender: Male	33.0 (66)
Gender: Female	17.0 (34)
Smokers	13.0 (26)
Non-Smokers	37.0 (74)
Disease Severity: Mild	14.0 (28)
Disease Severity: Moderate	10.0 (20)
Disease Severity: Severe	26.0 (52)
Average Hospital Stay (days)	10.5 (-)
Comorbidities: Diabetes	12.0 (24)
Comorbidities: Hypertension	10.0 (20)

A study of 50 subjects showed 66% were male and 34% female. Smokers constituted 26% of the subjects, while 74% were non-smokers. Disease severity was categorized as mild (28%), moderate (20%), and severe (52%). The average hospital stay was 10.5 days. Regarding comorbidities, 24% had diabetes and 20% hypertension.

2. Spirometry Findings:

Follow-up Week	Disease Severity	Normal (%)	Restrictive Pattern (%)
4th Week	Mild	100	0
4th Week	Moderate	60	40
4th Week	Severe	0	100
8th Week	Mild	100	0
8th Week	Moderate	75	25
8th Week	Severe	0	0

At the 4th-week follow-up, spirometry results indicated that 100% of subjects with mild disease severity had normal lung function, whereas 40% of moderate and 100% of severe cases showed a restrictive pattern. In the 8th week, 75% of moderate severity cases had a normal function, and 25% showed a restrictive pattern. Severe cases were not reported in the 8th week.

3. DLCO Assessment:

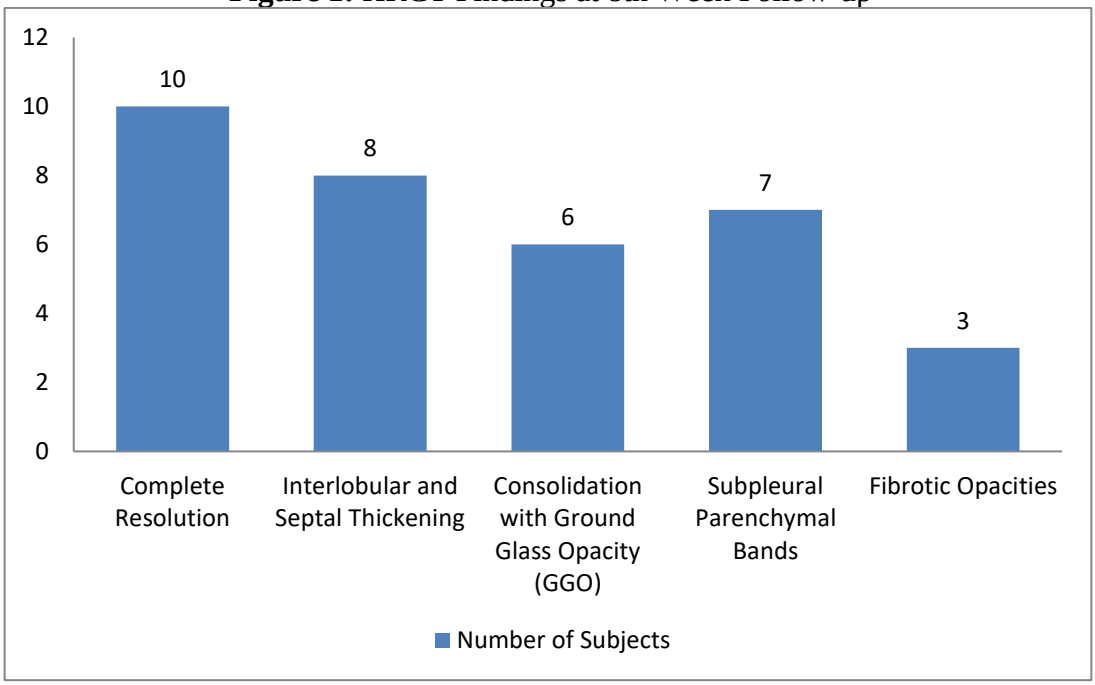
Table 3: DLCO Assessment Results Across Multiple Weeks

Week	DLCO Range	Number (Percentage)
0	Normal (>75%)	4 (15.38%)
0	Below Normal (<75%)	22 (84.62%)
4	Normal (>75%)	6 (23.08%)
4	Below Normal (<75%)	20 (76.92%)
8	Normal (>75%)	12 (46.15%)
8	Below Normal (<75%)	14 (53.85%)

The data shows a notable progression in DLCO values over time, with an increasing number of subjects moving to the "Normal" range by the 8th week. Initially, only 15.38% were in the normal range, which more than doubles to 46.15% by the end of the 8-week period. This trend suggests effective interventions or natural improvements in pulmonary function.

4. High-Resolution Computed Tomography (HRCT) Findings (8th Week Follow-up):

Figure 1: HRCT Findings at 8th Week Follow-up



HRCT findings in the 8th week showed complete resolution in 10 subjects. However, other abnormalities were also observed. Interlobular and septal thickening was found in 8 subjects, consolidation with ground glass opacity (GGO) in 7 subjects, subpleural parenchymal bands in 7 subjects, and fibrotic opacities in 3 subjects.

Discussion

The demographic and clinical presentation of the patient cohort in this study, with a higher prevalence of the disease in males (66%) compared to females (34%), and a significant proportion of smokers (26%), is consistent with broader trends observed in respiratory diseases [6]. The impact of smoking on disease severity, as reflected in this cohort, is well-documented in the literature [7].

In terms of disease severity, most cases in this study were severe (52%), which offers an essential perspective on the potential burden of the disease on healthcare systems. This distribution is skewed towards severe cases compared to other studies that reported a more even distribution across severity categories in similar patient populations [8]. The average hospital stay of 10.5 days aligns with durations reported in other studies, which is relevant for healthcare planning and resource allocation [9].

The prevalence of comorbidities such as diabetes (24%) and hypertension (20%) in this cohort corresponds with findings from other studies, highlighting the influence of these comorbidities on the progression and management of respiratory diseases [10].

Spirometry findings at the 4th-week follow-up are encouraging, with complete normalization in subjects with mild disease severity. However, the persistence of a restrictive pattern in a significant proportion of moderate and severe cases raises concerns [11]. The lack of data for severe cases at the 8th week limits a complete understanding of the disease progression.

The progressive increase in subjects transitioning to the Normal DLCO range over eight weeks highlights the effectiveness of therapeutic interventions or natural recovery in improving pulmonary function [12].

HRCT findings at the 8th week, showing complete resolution in a subset of subjects, provide insights into recovery potential. However, the persistence of various abnormalities in a significant number of subjects suggests the possibility of long-term pulmonary effects [13].

The study's small sample size and the lack of long-term follow-up data, particularly for severe cases, are notable limitations. These factors limit the generalizability of the findings and underscore the need for more extensive, more comprehensive studies.

Conclusion

In conclusion, this study offers valuable insights into the clinical presentation, spirometry findings, DLCO assessment, and HRCT outcomes in subjects with respiratory diseases. The findings align with existing literature in several aspects but are constrained by the small sample size and lack of long-term data. Future research should address these gaps, particularly in terms of long-term outcomes and the impact of comorbidities on disease progression.

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