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Research Article

Study of the Respiratory Sequelae in Covid-19 Patients from Tertiary Care Centre

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A B S T R A C T

Background: Coronavirus Disease 2019 (COVID-19), caused by SARS-CoV-2, has led to widespread morbidity, with emerging evidence of long-term pulmonary sequelae in recovered patients. While much focus has been placed on acute management, systematic evaluation of post-recovery respiratory function remains limited, especially in the Indian population. This study aimed to evaluate the clinical, functional, and radiological respiratory sequelae in patients recovering from varying severities of COVID-19 over a 12-month period.

Materials and Methods: A prospective cohort study was conducted at Northern Railway Central Hospital (NRCH), New Delhi, including 150 adult patients recovered from laboratory-confirmed COVID-19. Participants were categorised equally into mild, moderate, and severe groups based on initial illness severity. Exclusion criteria included pre-existing pulmonary or cardiac diseases. Clinical symptoms, pulmonary function tests (PFTs), the six-minute walk test (6MWT), and radiological findings (chest X-ray and CT) were evaluated at 3, 6 and 12 months post-discharge.

Results: Persistent dyspnoea and cough were more prevalent in the severe group and gradually improved over time. The severe group demonstrated significantly reduced oxygen saturation (mean SpO_2: 92% at 3 months), lower 6MWT distances (mean: 490.4 m), and higher Borg dyspnoea scores (mean: 6.9) compared to other groups ($p < 0.001$). Abnormal PFTs were most frequent in severe cases (82% at 3 months), with restrictive defects predominating. RALE scores and follow-up CT findings indicated sustained parenchymal abnormalities, including ground-glass opacities and interstitial thickening, especially in severe cases.

Conclusion: The majority of COVID-19 patients experienced clinical and functional improvement within the first 6 months post-recovery. However, those with initially severe disease had persistent respiratory impairments and radiological abnormalities even at 12 months. These findings underscore the need for structured long-term follow-up and pulmonary rehabilitation in patients recovering from severe COVID-19.

Keywords: COVID-19, SARS-CoV-2, Post-COVID sequelae, Pulmonary function

Introduction

Since December 2019, the world has been grappling with an unprecedented health crisis caused by the emergence of a novel coronavirus, Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2).[1] The initial outbreak, reported as a cluster of pneumonia cases in Wuhan, Hubei Province, China, was later identified to be caused by this novel virus. The World Health Organisation (WHO) officially declared Coronavirus Disease 2019 (COVID-19) a global pandemic on March 11, 2020, following the rapid spread of infections to over 110 countries.[2] In India, the first case was documented on January 30, 2020, in the state of Kerala. As of October 6, 2022, there have been over 616 million confirmed cases and more than 6.5 million deaths globally, with over 12.7 billion vaccine doses administered.[3]

SARS-CoV-2 is an enveloped RNA virus belonging to the Coronaviridae family, which also includes viruses responsible for SARS and Middle East Respiratory Syndrome (MERS).[4] The virus gains entry into human cells via the angiotensin-converting enzyme 2 (ACE2) receptor,[5] and its primary mode of transmission is through respiratory droplets and close contact. The incubation period ranges from 3 to 7 days, extending up to 14 days in some cases.[6] Although the clinical spectrum of COVID-19 varies, elderly individuals and those with comorbidities are more likely to experience severe illness,[7] while children and infants are not exempt from infection. The clinical course may progress rapidly to acute respiratory distress syndrome (ARDS), intensive care unit (ICU) admission, and even death in 4–15% of patients.[8]

Common initial symptoms include fever, dry cough, and malaise, although some patients may remain asymptomatic.[9] In severe cases, COVID-19 can lead to hypoxaemia, respiratory failure, and multi-organ dysfunction. Imaging modalities such as chest radiographs and computed tomography (CT) scans play a pivotal role in early detection and monitoring, especially when clinical presentation is non-specific.[10,11]

Although much attention has been devoted to the acute management and epidemiological characteristics of COVID-19, there is a growing body of evidence suggesting that a significant proportion of recovered patients experience persistent respiratory symptoms and structural lung abnormalities. Follow-up studies have demonstrated that COVID-19 can cause lasting damage to the lung parenchyma, including interstitial changes and fibrotic remodelling, leading to reduced pulmonary function and exercise tolerance.[12–14] Furthermore, some patients report ongoing breathlessness, fatigue, and functional disability even months after discharge, highlighting the need for systematic post-COVID evaluation and care.[15]

Given the scale of the pandemic and the increasing number of survivors, it is imperative to understand the long-term respiratory sequelae associated with SARS-CoV-2 infection. Clinical, radiological, and functional assessment of recovered patients is essential to identify those at risk of chronic pulmonary complications and to develop targeted rehabilitation strategies. This study aims to evaluate the respiratory sequelae in patients who have recovered from COVID-19 by assessing their clinical symptoms, pulmonary function tests, and radiographic findings during follow-up.

Materials and Methods

This prospective cohort study was conducted in the Department of General Medicine at Northern Railway Central Hospital (NRCH), New Delhi. A total of 150 adult patients who had recovered from laboratory-confirmed COVID-19 infection were enrolled. The study population was stratified into three equal groups of 50 patients each, based on the severity of their illness: mild, moderate, and severe, as per the "Interim Clinical Guidance for Management of COVID-19".[16]

Study Population and Eligibility Criteria

Patients included in the study were adults aged over 18 years who had been diagnosed with COVID-19 using an antigen-based assay and were discharged within the preceding three months. Stratified sampling was employed to select participants from among those who were previously admitted to the COVID-19 Centre and later followed up in the medicine outpatient department at NRCH. Exclusion criteria comprised patients with pre-existing chronic respiratory diseases such as chronic obstructive pulmonary disease (COPD), asthma, and interstitial lung disease, as well as those with known cardiac illnesses, including coronary artery disease (CAD), dilated or hypertrophic cardiomyopathy (DCMP/HOCM), and rheumatic heart disease (RHD).

Definition of COVID-19 Severity Categories

Patients were categorised into mild, moderate, or severe groups based on clinical parameters and radiological findings documented during their initial illness. Mild illness was defined by a respiratory rate (RR) of less than 24 breaths per minute and oxygen saturation (SpO_2) of ≥95% on room air without radiological evidence of pneumonia. Moderate illness was defined by a RR of 24–29 breaths per minute and SpO_2 of 90–94% on room air with evidence of pneumonia on imaging. Severe illness included patients with an RR ≥30 breaths per minute, SpO_2 <90% on room air, respiratory failure requiring ventilatory support, shock, or organ failure necessitating ICU admission.

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Recruitment Procedure

Baseline data were retrieved from inpatient and outpatient records of COVID-19 patients previously admitted to NRCH. Eligible participants were contacted telephonically, and verbal consent for participation was obtained after explaining the study objectives, potential risks, and benefits. The first 150 patients who agreed were enrolled, with written informed consent collected during their initial follow-up visit. Patients were scheduled for assessments at the 3rd, 6th, and 12th months post-discharge in the general medicine outpatient department.

Clinical and Radiological Evaluation

At each follow-up visit, detailed demographic and clinical data were recorded, including history of smoking, alcohol use, comorbid conditions (hypertension, chronic kidney disease, cerebrovascular disease, chronic liver disease), and symptoms experienced during hospital stay. A general physical examination and systemic examination of the respiratory system were conducted. Pulse oximetry was used to assess oxygenation on room air. Data on home oxygen therapy, CPAP/BiPAP use, and respiratory support requirements were also documented. Chest radiography (PA view) was performed in all patients, and chest CT scans were obtained when clinically indicated. Radiological findings were interpreted as per Fleischner Society criteria, and severity of lung involvement was assessed using the RALE score.[17]

Functional Status Assessment

Functional capacity was assessed using the six-minute walk test (6MWT), performed without supplemental oxygen in a standardised 50-meter corridor. Oxygen saturation and Borg dyspnoea scale scores were recorded pre- and post-walk. Standardised verbal encouragement was provided at fixed intervals, and the test was interrupted if any threatening symptoms developed.

Pulmonary Function Testing

Pulmonary function tests (PFTs) were conducted using the MIR (Italy) SPIROLAB III spirometer in a well-ventilated room. Parameters recorded included forced vital capacity (FVC), forced expiratory volume in 1 second (FEV_1), peak expiratory flow rate (PEFR), FEV_1/FVC ratio, FEF25–75%, and maximal voluntary ventilation (MVV). Spirometry was performed in a seated position according to ATS/ERS guidelines. Each parameter was measured thrice at 15-minute intervals, and the best of three readings was considered for analysis. Obstructive impairment was defined as FEV_1/FVC <0.70; restrictive impairment as FEV_1/FVC ≥0.70 and FVC <80%; and normal function was defined as FEV_1/FVC ≥0.70 and FVC ≥80%.

Results

A total of 150 patients with laboratory-confirmed COVID-19 pneumonia were enrolled and stratified equally into three groups based on disease severity: mild (n=50), moderate (n=50), and severe (n=50). All patients were followed up at 3, 6, and 12 months post-discharge. Of the severe group, 3 patients required domiciliary oxygen therapy during follow-up. The mean (±SD) age in the mild group was 46.2 ± 11.7 years, 45.1 ± 11.5 years in the moderate group, and 47.4 ± 11.2 years in the severe group. The difference in age between the groups was not statistically significant (ANOVA, $p = 0.612$). The gender distribution was comparable across the groups, with males accounting for approximately 62–64% in all three groups (chi-square test, $p = 0.972$) (Table1).The prevalence of alcohol use, smoking, hypertension, and diabetes was similar across the groups. However, chronic liver disease was reported only in the severe group (12%), which was statistically significant ($p = 0.002$). No patients in the mild or moderate groups had chronic kidney or liver disease.

During follow-up, dyspnoea and cough were the most commonly reported symptoms. Dyspnoea was assessed using the Modified Medical Research Council (MMRC) scale. At 3 months, median dyspnoea scores were significantly higher in the severe group (3.0) compared to the moderate (1.0) and mild (1.0) groups ($p < 0.001$, Kruskal-Wallis test). This trend persisted at 6 and 12 months, although scores declined over time. Cough scores also showed a significant difference across the groups at all time points (3, 6, and 12 months), with higher scores in the severe group ($p < 0.001$). Within-group changes over time were not statistically significant. Rhonchi and crepitations were observed more frequently in the severe group at all time points. At 3 months, 10% of patients in the severe group had rhonchi, and 42% had crepitations, compared to 2% and 6% in the mild group, respectively. These differences were statistically significant ($p < 0.001$), and the trend continued at 6 and 12 month. The mean SpO_2 at 3 months was significantly lower in the severe group (92 ± 8%) compared to the moderate (97 ± 3%) and mild (98 ± 2%) groups ($p < 0.001$, ANOVA). This difference persisted through 6 and 12 months. Similarly, heart rate was significantly higher in the severe group at all time points (3, 6, and 12 months), with the highest mean rate at 3 months (110 ± 16 bpm) ($p < 0.001$). Abnormal pulmonary function was more common in the severe group. At 3 months, 41 (82%) patients in the severe group had abnormal PFTs, compared to 34 (68%) in the moderate and 10 (20%) in the mild group. This difference was statistically significant ($p < 0.001$). The proportion of abnormal PFTs decreased at 6 and 12 months but remained significantly higher in the severe group (Table 2).Obstructive, restrictive, and mixed patterns were classified and analysed, with a

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predominance of mild to moderate restrictive defects in severe and moderate groups. Severe restrictive changes were observed only in the severe group (12% at 3 months, 6% at 6 months, and 6% at 12 months). The mean six-minute walk distance (6MWD) at 3 months was lowest in the severe group (490.4 ± 70.8 m), followed by moderate (527.5 ± 53.5 m) and mild (538 ± 56.8 m). This difference was statistically significant at all time points ($p < 0.001$). The Borg dyspnoea scores at 3 months were 1.3 ± 0.4 in the mild, 4.2 ± 1.4 in the moderate, and 6.9 ± 1.2 in the severe group. These scores significantly improved over time but remained higher in the severe group ($p < 0.001$) (Table 3).

Chest X-ray findings, assessed using the RALE score, demonstrated higher scores in the severe group across all follow-up points. At 3 months, the median RALE score in the severe group was 4.5 (Q1: 3.0, Q3: 6.0) compared to 2.0 in the mild and moderate groups ($p < 0.001$). Though scores improved by 12 months, the difference remained statistically significant. Baseline CT scans done during hospitalisation revealed a significantly higher mean CT severity score in the severe group (21 ± 2) compared to the moderate group (15 ± 1) ($p < 0.001$, Mann–Whitney U test). Follow-up CT scans were available for 5 patients in the moderate group and 21 in the severe group. Ground-glass opacities were noted in 60% and 57.1% of patients in the moderate and severe groups, respectively. Interstitial thickening and reticular patterns were more frequent in the severe group (71% and 38.1%, respectively), but the differences in CT patterns between the groups were not statistically significant (chi-square test, $p > 0.05$).

Table 1.Demographic Distribution of Study Participants

Variable	Mild (n=50)	Moderate (n=50)	Severe (n=50)	p-value
Age (Years)	46.2 ± 11.7	45.1 ± 11.5	47.4 ± 11.2	0.612
Sex				0.972
Male	31 (62.0%)	31 (62.0%)	32 (64.0%)	
Female	19 (38.0%)	19 (38.0%)	18 (36.0%)	

Table 2.Pulmonary Function Test Interpretation at 3, 6, and 12 Months Follow-Up

Interpretation	3 Months Mild	3M Moderate	3M Severe	6M Mild	6M Moderate	6M Severe	12M Mild	12M Moderate	12M Severe
MILD O	1 (2.0%)	2 (4.0%)	1 (2.0%)	1 (2.0%)	2 (4.0%)	1 (2.0%)	1 (2.0%)	2 (4.0%)	1 (2.0%)
MILD O+R	0 (0.0%)	1 (2.0%)	0 (0.0%)	0 (0.0%)	1 (2.0%)	0 (0.0%)	0 (0.0%)	1 (2.0%)	0 (0.0%)
MILD R	9 (18.0%)	22 (44.0%)	17 (34.0%)	5 (10.0%)	16 (32.0%)	18 (36.0%)	4 (8.0%)	14 (28.0%)	19 (38.0%)
MOD R	0 (0.0%)	9 (18.0%)	13 (26.0%)	0 (0.0%)	4 (8.0%)	12 (24.0%)	0 (0.0%)	1 (2.0%)	10 (20.0%)
MOD O	0 (0.0%)	0 (0.0%)	1 (2.0%)	0 (0.0%)	0 (0.0%)	1 (2.0%)	0 (0.0%)	0 (0.0%)	1 (2.0%)
MOD R+O	0 (0.0%)	0 (0.0%)	1 (2.0%)	0 (0.0%)	0 (0.0%)	1 (2.0%)	0 (0.0%)	0 (0.0%)	1 (2.0%)
SEVERE R	0 (0.0%)	0 (0.0%)	6 (12.0%)	0 (0.0%)	0 (0.0%)	3 (6.0%)	0 (0.0%)	0 (0.0%)	3 (6.0%)
SEVERE R+O	0 (0.0%)	0 (0.0%)	2 (4.0%)	0 (0.0%)	0 (0.0%)	2 (4.0%)	0 (0.0%)	0 (0.0%)	2 (4.0%)
Normal	40 (80.0%)	16 (32.0%)	9 (18.0%)	44 (88.0%)	27 (54.0%)	12 (24.0%)	45 (90.0%)	32 (64.0%)	13 (26.0%)
Chi-square p-value	<0.001			<0.001			<0.001		

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Table 3.6 minute walk test (6MWT) comparison on Borg scale of dyspnea

Time	GROUP									Kruskal Wallis test P value
	Mild			Moderate			Severe			
	Median	Q1	Q3	Median	Q1	Q3	Median	Q1	Q3	
3 months	1.0	1.0	2.0	4.0	3.0	5.0	7.0	6.0	8.0	<0.001
6 months	1.0	1.0	1.0	2.0	2.0	3.0	3.0	2.0	4.0	<0.001
12 months	1.0	1.0	1.0	1.0	1.0	2.0	1.0	1.0	1.0	<0.001

Discussion

As the COVID-19 pandemic has evolves and effective therapeutic strategies and vaccines have emerged, attention has gradually shifted toward understanding the long-term consequences of SARS-CoV-2 infection. While numerous clinical studies have addressed the acute epidemiological and clinical characteristics of COVID-19, limited research has focused on long-term follow-up of discharged patients. Existing literature suggests that the disease can cause significant post-recovery sequelae, including physiological and radiological changes, particularly within the pulmonary system. Interstitial lung changes and pulmonary fibrosis have been reported in follow-up imaging, indicating potential long-term morbidity.

In the present study, we prospectively followed 150 patients with mild, moderate, and severe COVID-19 pneumonia for a period of one year to assess clinical symptoms, pulmonary function, and radiological changes post-recovery. Patients were evaluated at 3, 6, and 12 months after discharge. We observed that respiratory symptoms such as dyspnoea and cough were most prevalent during the early follow-up period, especially in patients with severe illness. These symptoms improved progressively over time, although within-group comparisons across time intervals did not yield statistically significant differences ($p > 0.05$). However, when compared across severity groups at each follow-up time point, the differences were statistically significant ($p < 0.001$). This finding aligns with previous studies, where dyspnoea was reported in 42%–66% of patients during early follow-up (60–100 days) [18]. Similarly, a bicentric prospective study showed reductions in fatigue (from 58% to 46%) and shortness of breath (from 36% to 21%) over a 1-year period in hospitalised COVID-19 patients.[19]

Our findings further revealed that pulmonary functional capacity improved with time in most patients, particularly those with mild and moderate illness. By the 12-month follow-up, normal pulmonary function was observed in 90% of the mild group, 64% of the moderate group, and only 26% of the severe group. Although there was a trend toward recovery, patients with severe disease demonstrated persistent restrictive abnormalities. These findings are consistent with earlier reports. A previous study indicated that post-COVID patients may develop persistent restrictive and small airway dysfunction, often unrelated to initial disease severity.[20] In contrast, Mo et al. identified reduced diffusion capacity and restrictive defects as correlating strongly with illness severity. A longitudinal study by Wu et al.[21] on 83 patients also demonstrated gradual improvement in lung function and exercise tolerance at 3, 6, 9, and 12 months post-hospitalisation.

Functional capacity, as assessed by the six-minute walk test (6MWT), showed significant group-wise differences at each time point ($p < 0.001$). However, the rate of improvement over time plateaued after 6 months. Similar trends were reported in previous studies, where median 6MWT distance remained below normal in approximately one-quarter of patients even at 6 months.[21]

Radiological assessment through chest X-rays and computed tomography (CT) imaging demonstrated progressive resolution in most cases. In our study, chest X-ray findings evaluated using the RALE scoring system showed statistically significant differences among the groups at all time points. However, comparison over time within individual groups showed limited improvement after the 6-month interval. CT imaging revealed persistent abnormalities, including ground-glass opacities (GGO), interstitial thickening, and reticular patterns, particularly in severe cases. Among 21 severe cases who underwent follow-up CT, 57.1% had GGO, 71% interstitial thickening, and 38.1% reticular patterns. These results are in line with reports by other investigators, where persistent HRCT abnormalities were observed in one-third of patients even after 12 months.[22] However, a Chinese cohort study reported no evidence of established fibrosis or progressive interstitial changes at 9 and 12 months.[23]

An important observation in our study was that the majority of functional and radiological recovery occurred within the

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first 3 to 6 months post-discharge, after which the degree of improvement declined. This temporal trend has also been observed in earlier studies. For instance, a pilot study on a 70-year-old patient with severe COVID-19 pneumonia requiring mechanical ventilation documented complete clinical and functional recovery by 6 months.[24] Conversely, long-term data from SARS survivors suggest that interstitial changes and functional impairment may persist for up to two years before stabilisation.[25] A recent follow-up cohort study in a Scottish population demonstrated that 6% of symptomatic COVID-19 patients remained unrecovered, and 42% only partially recovered at 6, 12, and 18 months post-infection.

Importantly, we found that patients with mild and moderate illness largely returned to baseline function and radiological normalcy. However, among those with severe disease, a substantial proportion exhibited persistent abnormalities associated with functional impairment. In line with our findings, a study on recovered COVID-19 patients reported that 85.7% of those with severe pneumonia had residual lung fibrosis, and these patients also demonstrated abnormal pulmonary function.[26]

Conclusion

This prospective study demonstrated that most COVID-19 pneumonia patients showed clinical, functional, and radiological improvement over a 12-month follow-up, with the majority of recovery occurring within the first 3 to 6 months. Functional capacity, assessed through the six-minute walk test and pulmonary function tests, improved in all groups, though many patients in the severe category continued to exhibit residual impairment, likely due to lasting lung damage. Radiological resolution was complete in most mild and moderate cases, but persistent abnormalities were common in the severe group. These findings underscore the importance of long-term follow-up, especially for patients with severe disease.

Limitations

This study was limited to a single centre with participants mainly from the Delhi-NCR region, which may affect generalisability. The sample size was modest, with 50 patients per group. Additionally, follow-up CT scans were performed only in symptomatic patients or when treatment changes were needed, potentially underestimating persistent radiological changes.

Conflict of Interest: None

Declaration of Generative AI and AI-Assisted Technologies in the Writing Process: None

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