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OPEN

# Efficacy of Early Inpatient Rehabilitation of Post-COVID-19 Survivors

## Single-Center Retrospective Analysis

Ning Cao, MD, Jaclyn Barcikowski, DO, Franklin Womble, MD, Bianca Martinez, MD, Yevgeniya Sergeyenko, MD, Jacob H. Koffer, MD, Michael Kwasniewski, MD, Thomas Watanabe, MD, Rui Xiao, PhD, and Alberto Esquenazi, MD

**Objective:** The aim of this study was to understand the demographic, clinical characteristics, and effectiveness of early inpatient rehabilitation of post-COVID survivors.

**Design:** A single-center retrospective chart review analysis of 100 patients admitted to a newly created acute COVID rehabilitation unit (CORE+) from April to December 2020 was conducted.

**Results:** The demographic and clinical characteristics and complications of 100 post-COVID patients were reviewed. Functional outcomes of GG Self-care and Mobility Activities Items (Section GG0130 and GG0170) of the Centers for Medicare & Medicaid Services of the Inpatient Rehabilitation Facility Patient Assessment Instrument (Version 3.0) at admission and discharge, prevalence of oxygen requirement, the need for cognitive and neuropsychology support by discharge, and dispositions after completion of inpatient rehabilitation facility stay were analyzed. The functional outcomes of 59 primary pulmonary manifestations of COVID patients were further analyzed based on the presence of intensive care unit stay before transfer to the COVID rehabilitation unit. Most patients demonstrated significant functional gains after completion of inpatient rehabilitation facility stay; however, a considerable number of patients continued to require cognitive support by discharge.

**Conclusion:** The data suggested the benefit of early rehabilitation for hospitalized post-COVID patients. Services need to be geared to include patients' cognitive deficits.

**Key Words:** Inpatient Rehabilitation, Functional Outcomes, Post-COVID, Post-ICU Syndrome

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In late 2019, a highly pathogenic novel coronavirus (COVID-19) causing severe acute respiratory syndrome (SARS)-CoV-2 emerged in Wuhan, China, and soon spread throughout the world, causing a global pandemic.<sup>1,2</sup> Many patients with COVID-19 infection required prolonged hospitalization, assisted ventilation, and critical care management. As a result, many COVID-19 survivors developed deconditioning; physical, cognitive, and psychologic sequelae; and persistent respiratory problems,<sup>3–5</sup> as well as other complications that are even now not fully appreciated. Data from countries initially affected by the pandemic demonstrated that the rapid spread of the infection quickly overloaded their national health systems.<sup>6,7</sup>

Historical data from Medicare suggest that more than 30% of patients hospitalized with sepsis, a condition with inpatient mortality like that associated with COVID-19, require facility-based care.<sup>8</sup> Post acute care often serves as a “pop-off valve” for hospital capacity, in that transferring patients to a such a setting once they recover from the most acute phase of their illness could free up acute care hospital beds.<sup>9</sup> Because of the COVID-19 patient surge, along with reallocation of post-acute care facilities as acute care spaces and workforce depletion, post acute care became strained, as was first seen in the major cities of Boston and New York City.<sup>10</sup>

At the authors' institution, a specialized acute inpatient rehabilitation unit to address the functional and medical needs of post-COVID patients early after the critical acute care phase was created, as well as for those patients in need of inpatient rehabilitation for another reason but who became actively infected. The development of a dedicated “center of excellence” specializing in and assuming the care of patients recovering from COVID-19 was developed through what was termed the CORE+ unit (COVID rehabilitation unit).<sup>11</sup> Patients would undergo a comprehensive rehabilitation program with a multidisciplinary team with staff provided appropriate safety equipment, training, and adequate personal protective equipment to provide this care safely. The unit opened in April 2020 and closed on July 1, 2021. The alpha and delta variants of COVID-19 were the dominant strains during this time period.

This study reports on the demographics, clinical characteristics, and functional outcomes, including cognitive/psychologic and ultimate discharge destination, of the patients treated in the CORE+ unit from April 2020 to December 2020 (before vaccines were available). The purpose of this retrospective review has many folds. The comorbidities and clinical characteristics of the hospitalized COVID patients were analyzed to assess any underlying factors contributing to the patients who might have a risk of developing primary respiratory

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symptoms as opposed to those in the cohort with minimal respiratory symptoms after COVID infection. Furthermore, the physical and cognitive aspects of outcomes were analyzed in the primary COVID-19 patients who received ventilator vs. no ventilator treatment to evaluate how patients with different severities of respiratory disease responded to interdisciplinary treatment in the CORE+ unit.

The results are intended to provide insights on the effectiveness of early interdisciplinary rehabilitation for post-COVID survivors, particularly given that the potential risk factors and rehabilitation needs of patients with severe COVID disease and their trajectory of recovery were not known.

## METHODS

### Statistical Analysis

The demographic and clinical characteristics of the patients were summarized by standard descriptive statistics, that is, mean and standard deviation (SD) or median and interquartile range (IQR) for continuous variables as appropriate and count and percentage for categorical variables. Comparisons between groups were done by two-sample *t* test or Wilcoxon ranks sum test for continuous variables and by chi-square test or Fisher exact test for categorical variables. A prespecified significance level of 0.05 (two sided) was used for all analyses. Statistical analyses were performed using STATA 15.0 (College Station, TX). The medical records of 100 patients admitted in the CORE+ unit from April to December 2020 were included for review and no records were excluded.

Exemption from institutional review board review and waiver of informed consent were approved as a retrospective chart review study.

### Participants

This retrospective review included 100 patients admitted to the CORE+ unit consecutively from April 2020 to December 2020. Admission criteria were variable during the period of retrospective study. Initially, any patient from within or outside the authors' institution who met the following admission criteria was considered to the CORE+ unit<sup>7</sup>: 7 days from the diagnosis of COVID-19; at least 72 hrs nonfebrile without taking fever-reducing medication; may have a tracheostomy but no need for prescribed suction; oxygen need  $\leq$  5 L at rest; improving COVID-19-related symptoms and in need of rehabilitation, while also considering individual psychosocial needs such as home environment and impact on family members; non-COVID (+) rehabilitation unit patients who became positive on screening and developed mild symptoms; and ability to tolerate and participate 3 hrs per day of therapy (physical therapy, occupational therapy, and/or speech therapy) 5 to 7 days per week in commensurate with inpatient rehabilitation facility (IRF) requirements under the regulation of the Centers for Medicare & Medicaid Services. The isolation ended based on the polymerase chain reaction testing result initially; later in the pandemic, the isolation precaution was based on symptom-based strategy as per the Centers for Disease Control and Prevention guideline<sup>12</sup> that was in effect at the given time.

### Outcomes

The electronic medical records of patients admitted to the CORE+ unit during April to December 2020 were reviewed. Patients' demographics (age, sex, and body mass index), comorbidities, length of hospital stay (including intensive care unit [ICU]) before transfer to rehabilitation, length of rehabilitation stay, and data regarding newly developed thromboembolic complications were collected.

In addition, the functional outcomes assessed at admission and discharge were composed of GG Self-care and Mobility Activities Items (Section GG0130 and GG0170) of the Centers for Medicare & Medicaid Services-issued Inpatient Rehabilitation Facility Patient Assessment Instrument Version 3.0; speech/cognitive therapy need as assessed by speech and occupational therapists using various tools including the Orientation log (O-Log), Montreal Cognitive Assessment, Saint Louis University Mental Status, and Cognitive Linguistic Quick Test based on patients' clinical characteristics; supplemental oxygen requirement; the need for neuropsychology support; and disposition to home/acute care/skilled nursing facility setting after completion of IRF.

### Intervention

The admission criteria warranted providing early intensive rehabilitation program in post-acute COVID-19 patients. The functional status of individuals at admission was thoroughly assessed by the multidisciplinary team composed of psychiatrists and medical consultants, physical therapists, occupational therapists, speech therapists, neuropsychologists, respiratory therapists, and rehabilitation nursing to capture the full range of consequences of COVID-19 infection. The patient-tailored treatment protocol was determined by team evaluation and prioritized taking the patients' goals into account. The program was delivered in 3 hrs of one-on-one treatment per day and 5 to 7 days per week in a contained environment with separated gym space and equipment. For patients who required respiratory support, the treatment plan incorporated pulmonary rehabilitation including but not limited to optimization of overall medical management, progressive exercise protocol with closely monitored vital signs and pulse oximetry, energy conservation techniques, and respiratory physiotherapy.<sup>12,13</sup> In addition, the mobility and daily activity functional training activities were tailored to address the individual's functional deficits.<sup>13</sup> For patients with cognitive impairment, cognitive therapy involved a combination of remediation through direct training, metacognitive strategy instruction, and use of compensatory techniques.<sup>14</sup> All patients were able to access daily speech/swallow pathology and neuropsychology service for cognition assessment and psychological support as well, if needed.<sup>14,15</sup>

## RESULTS

Among the 100 patients admitted to the CORE+ unit, 59 (mean age,  $65 \pm 13.2$  yrs) were admitted because of functional impairment primarily stemming from COVID-19 (the primary pulmonary cohort). The remaining 41 patients (mean age,  $62 \pm 16.7$  yrs) were admitted because of other debility diagnoses (the COVID-19 coinfection cohort), with coincident coinfection with COVID-19 (positive polymerase chain reaction test result or mild symptoms, but no need for active

**TABLE 1.** Clinical characteristics comparison between COVID-19 patients with primary pulmonary manifestation and patients with other rehabilitation diagnosis with COVID-19 coinfection in the CORE+ unit

	COVID 19 With Primary Pulmonary	COVID-19 Coinfection	P
No. of patients	59	42	
Age, mean (SD), years	65 (13.2)	62 (16.7)	0.34
Sex, n (%)			1.0
Male	31 (52.5)	22 (52.4)	
Female	28 (47.5)	19 (45.2)	
BMI, mean (SD), kg/m <sup>2</sup>	30 (7.6)	28.6 (6.1)	0.31
Habitual smokers, n (%)	14 (23.7)	14 (33.3)	0.40
Comorbidities, n (%)			
Hypertension	48 (81.4)	26 (61.9)	0.051
Diabetes type 2	23 (40)	18 (42.9)	0.85
Cardiac dysfunction	23 (40)	21 (50)	0.37
COPD	8 (14)	3 (7.1)	0.35
Kidney disease	13 (22)	10 (23.8)	1.0
Malignance	5 (8.5)	6 (14.3)	0.52
Complications, n (%)			
DVT	5 (8.5)	1 (2.4)	0.40
Pulmonary embolism	5 (8.5)	3 (7.1)	1.0

BMI indicates body mass index; COPD, chronic obstructive pulmonary disease; DVT, deep vein thrombosis.

treatment; Table 1). Among the 41 rehabilitation patients with COVID-19 coinfection, stroke (15), spinal cord injury (11), and medical complex patients (8) comprised most of the primary rehabilitation diagnoses. The demographic and clinical characteristics of these two cohorts were compared and analyzed. No statistically significant differences were found between the two cohorts in terms of age, sex, body mass index, or other comorbidities. Body mass index in both groups was categorized as overweight/obese or not. Hypertension was the most common comorbidity identified in both cohorts ( $P = 0.051$ ),

followed by cardiac disease (including heart failure, coronary artery disease, cardiac surgery, and atrial fibrillation) and diabetes, prevalent among 40%–50% of patients. Fewer than 15% of patients had a history of chronic obstructive pulmonary disease; approximately 20%–30% were recorded as active smokers (Table 1).

In terms of thromboembolic complications developed in acute care as well as in the CORE+ unit, a slightly higher rate of deep vein thrombosis was detected in the primary pulmonary cohort, but this difference was not statistically significant

**TABLE 2.** Demographic and clinical characteristics of patients with primarily pulmonary manifestations of COVID-19 stratified by requirement for invasive mechanical ventilation while in the acute care hospital

	COVID-19 Patients With Primary Pulmonary Presentation		P
	Ventilation Before IRF	No Ventilation Before IRF	
No. of patients	14	45	
Age, mean (SD), years	63 (11.6)	67 (12)	0.28
Sex, n (%)			0.37
Male	9 (64)	22 (49)	
Female	5 (36)	23 (51)	
BMI, mean (SD), kg/m <sup>2</sup>	30 (6.4)	30 (7.6)	1.0
Habitual smokers, n (%)	2 (14)	12 (27)	0.48
Comorbidities, n (%)			
Hypertension	13 (93)	35 (78)	0.27
Diabetes type 2	6 (43)	17 (38)	0.76
Cardiac dysfunction	5 (36)	18 (40)	1.0
COPD	2 (14)	6 (13)	1.0
Kidney disease	2 (14)	11 (24)	0.71
Malignance	1 (7)	4 (9)	1.0
Complications, n (%)			
DVT	2 (14)	2 (4)	0.24
Pulmonary embolism	3 (21)	3 (6.7)	0.14

BMI indicates body mass index; COPD, chronic obstructive pulmonary disease; DVT, deep vein thrombosis.

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**TABLE 3.** Rehabilitation outcomes in COVID-19 patients with primary pulmonary manifestation

	Post-ICU	Without ICU	P
No. of patients	14	45	
ICU LOS, median (IQR)	9.0 (4.0, 11.8)	NA	NA
Acute care LOS, median (IQR)	18 (16, 26)	10 (7, 13)	<0.0001 <sup>a</sup>
Rehabilitation LOS, median (IQR)	13 (10, 16)	12.5 (11, 15.3)	0.62
Section GG functional measure			
PT (mobility), mean (SD)			
Admission	27 (8.0)	31 (12.4)	0.17
Discharge	71 (22.3)	72 (22.96)	0.89
Functional change	44 (21.3)	41 (18.2)	0.64
OT (self-care), mean (SD)			
Admission	19 (19.2)	20 (5.4)	0.85
Discharge	35 (8.3)	34 (9.2)	0.70
Functional change	17 (7.5)	14 (6.4)	0.19
SLP cognitive support, n (%)			
Admission	11 (78.6%)	34 (75.6%)	1.0
Discharge	5 (35.7%)	28 (62.2%)	0.12

<sup>a</sup>  $P < 0.05$ .

LOS indicates length of stay; OT, occupational therapy; PT, physical therapy; SLP, speech therapy.

compared with the rate of deep vein thrombosis diagnosed in the COVID-19 coinfection cohort (Table 1).

Among the 59 patients who presented primarily for acute respiratory manifestations due to COVID-19 infection, 14 required invasive mechanical ventilation. The demographic and clinical characteristics of the cohort were further analyzed and compared based on the need for mechanical ventilation. The prevalence of chronic obstructive pulmonary disease was similar in patients who did or did not require mechanical ventilation (13% vs. 14%,  $P = 1.0$ ). Hypertension, diabetes mellitus, and cardiac pathology were among the most prevalent comorbidities in both groups of patients (Table 2). Deep vein thromboses and pulmonary emboli were more common in patients who received mechanical ventilation than in patients who did not receive mechanical ventilation, but these differences were not statistically significant (14% and 21% vs. 4% and 6.7%,  $P = 0.24$  and  $P = 0.14$ ). Five post-ICU patients developed critical illness neuropathy/myopathy, which were based on physical examination on admission (later confirmed by electromyography/nerve conduction study). The diagnosis of post-intensive care syndrome, defined as new or worsened physical, cognitive, and/or mental health impairment that persists after ICU stay, was attempted by interdisciplinary team assessment on admission<sup>4,15</sup>; however, physical/mental decline was highly prevalent in both cohorts, which might have been confounded by the impact of COVID-19 infection.

The functional outcomes were further analyzed in the group of patients who required ventilation or experienced an ICU stay. Compared with the patients who did not experience an ICU stay, they had a similar length of rehabilitation stay (13 post-ICU vs. 12.5 non-ICU, 3 and 12.5 was based on median [IQR]), but a significantly longer acute care length of stay (18 vs. 10  $P < 0.05$ ) before transfer to the CORE+ unit. All of the patients had significant functional gains in the occupational therapy and physical therapy GG section scale (shown in

Table 3). In terms of cognitive impairment assessed by speech and occupational therapists, more than 70% of the patients in both groups needed cognitive therapy support on admission. Although most of the patients responded to cognitive rehabilitation treatment, approximately 30% of post-ICU patients required continuous cognitive therapy on discharge. Cognitive impairment was also persistent in approximately 60% of patients who did not require ventilator treatment. It was observed that orientation was mostly improved in these patients at discharge, but deficits in memory, attention to details, and information processing persisted.

Other aspects of outcomes were analyzed, as shown in Table 4. The percentage of patients who experienced mood changes (primarily anxiety and depression) that required neuropsychology support was not significantly different between the two groups. The number of patients who had

**TABLE 4.** Other outcomes in COVID-19 patients with primary pulmonary manifestation

	Post-ICU	Without ICU	P
Neuropsychology need, n (%)	1 (7.1)	7 (15.5)	0.67
Dysphagia, n (%)			
Admission	5 (35.7)	7 (15.6)	0.13
Discharge	0 (0)	1 (2)	1.0
Oxygen requirement, n (%)			
Admission	6 (42.9)	21 (46.7)	1.0
Discharge	0 (0)	2 (4.4)	1.0
Disposition, n (%)			0.038 <sup>a</sup>
Home	11 (78.6)	44 (97.8)	
SNF	1 (7.1)	0 (0)	
Acute	2 (14.3)	1 (2.2)	

<sup>a</sup>  $P < 0.05$ .

SNF indicates skilled nursing facility.

difficulty swallowing after ICU stay was greater than that in the group of patients who did not experience an ICU stay, but most of the patients completely recovered by discharge. A similar phenomenon was observed in the outcomes of pulmonary rehabilitation. Although more than 40% of patients required new supplemental oxygen (since COVID infection) on CORE+ unit admission, almost all patients were able to be weaned off oxygen by discharge. There were no significant differences observed in the patients who required ventilator treatment. In comparison with the patients who did not experience an ICU stay, the post-ICU patients had a statistically significant higher rate of acute care transfers (14.3%) and discharges to skilled nursing facility (Table 4). Length of stay and disposition were primarily driven by their achieved independence level and family support needed while also being impacted by the general guidelines of individual insurance payer.

## DISCUSSION

Based on the analysis, there was no significant difference in baseline demographic and clinical characteristics identified to contribute to the risk of developing debilitated pulmonary symptoms when compared with the group without significant respiratory symptoms after COVID-19 infection. The clinical characteristics of the cohort of patients in this study did have a higher prevalence of obesity (100%), hypertension (70%–90%), and diabetes (>40%) than other published cohorts in Austria,<sup>16</sup> France, and United Kingdom,<sup>17</sup> but comparable with characteristics found in other cohorts in North America.<sup>18,19</sup>

In comparison with the rehabilitation outcomes from other inpatient rehabilitation facilities,<sup>19,20</sup> it was observed that the post-COVID survivors who met the acute inpatient rehabilitation admission criteria set up for the CORE+ unit demonstrated excellent potential to regain their previous physical independence and return to community after a relatively short rehabilitation stay regardless of their previous ICU stay. The average of length of stay (around 15 days) for the primary pulmonary COVID patients in the CORE+ unit was comparable with that (around 14 days) for the medically complex patients admitted to the non-COVID rehabilitation unit during the same period. With regard to respiratory functional outcomes, it was observed that most post-COVID-19 patients recovered considerably well from a pulmonary standpoint as they generally did not require any oxygen support on discharge from IRF.

It is important to highlight in this study that cognitive impairment was found to be quite prevalent in the hospitalized COVID-19 patients and seemed more challenging to address,<sup>21</sup> even in the patients who did not receive intubation or stay in the ICU. Although there is greater appreciation for this now, at the time, there was much less information regarding this important complication. The mechanisms of the neurologic sequelae of post-COVID-19 infection are multifactorial and had been widely reported.<sup>2,4,11</sup> Therefore, cognitive assessment on admission for COVID-19 patients is essential for rehabilitation, and community rehabilitation support must be geared to the needs of patients with cognitive decline and other nonpulmonary manifestations that could play a major role in the long COVID-19 recovery and to optimize quality of life. Based on the findings, a framework was developed and implemented in the COVID outpatient clinic to include Saint Louis

University Mental Status Examination and health-related quality of life-14 as part of the assessments, in addition to the 6-min walk and forced expiratory volume in 1 sec, to track patients' recovery after being discharged from the CORE+ unit.

The authors would like to stress that of the severely affected patients who received ventilation treatment, 85.7% were able to complete the program and presented a good response to the rehabilitation program in their institution. However, the acute transfer and skilled nursing facility discharge rate were significantly higher in patients who received mechanical ventilation. This may imply that post-intensive care syndrome might have played a role in hindering them from reaching community independence. This finding is consistent with the outcomes observed from other rehabilitation centers with similar settings.<sup>19,22</sup> In contrast, Curci et al.<sup>23</sup> reported that 41 post-ICU COVID patients in Italy who received less intensive (two 30-min sessions daily) rehabilitation treatment had a much longer length of stay ( $31.97 \pm 9.06$  days) to reach their baseline function, although notably the mean age of the cohort was older ( $72.15 \pm 11.07$  yrs) than the other cohorts. This might suggest that higher intensity of therapy could be more beneficial and potentially help the patients achieve independence in a shorter period.

## Limitations

The authors need to point out that this study reports only on unvaccinated patients with COVID-19 (alpha and delta variants) admitted for inpatient rehabilitation care based on admission criteria that included assessment of potential to recover. Therefore, the results are not necessarily representative of the entire COVID-19 population, especially with changes in COVID-19 variants and acute infection management. These data might not be generalized to other rehabilitation centers with different admission criteria or IRF regulation internationally.

## CONCLUSION

Tremendous efforts made to advance therapeutic interventions resulted in reducing the mortality of patients with severe COVID-19 illness. However, functional impairment for most survivors and their recovery process has not been fully addressed owing to the overwhelmed acute care system, including rehabilitation centers, in highly prevalent regions. Fortunately, the authors' institution was one of the first inpatient facilities that were able to respond in a timely manner during the first and second pandemic waves before vaccination and provided effective acute inpatient rehabilitation service to meet patients' needs. The early multidisciplinary team treatment proved to be an effective approach to maximize their independence, efficiently utilize healthcare resources, and prepare this vulnerable population for the future. These data reflect the outcomes of a single rehabilitation center but are a valuable contribution to the current limited understanding of the recovery process in hospitalized COVID-19 survivors. The experience will also help to design rehabilitation programs geared to the expanding spectrum of nonpulmonary involvements in COVID-19 patients. To the authors' best knowledge, the data presented are the one of very few studies to investigate comprehensively a post-acute care cohort of COVID-19 patients regarding their functional status and rehabilitation intervention and outcomes.<sup>3</sup>

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