Impairment in Physical Function and Mental Status in a Survivor of Severe COVID-19 at Discharge from an Acute Care a Hospital: A Case Report

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ABSTRACT. Background: Early mobilization and rehabilitation interventions should be provided to patients who survived severe COVID-19 to improve their physical function and activities of daily living (ADL). However, their physical and mental status at discharge has not been well described in Japan. We report the intervention provided for a survivor of severe COVID-19 and his physical and mental status at discharge from an acute care hospital. Case Report: A 62-year-old man was admitted to our emergency department with a diagnosis of COVID-19 with severe acute respiratory dysfunction. He had complicated intensive care unit-acquired weakness (ICU-AW) and delirium during mechanical ventilation therapy. Rehabilitation intervention was initiated on the seventh day post-admission and was gradually performed according to his respiratory and hemodynamic status. As a result of the rehabilitation intervention, ICU-AW and cognitive function gradually improved. On hospital day 37, he independently performed basic ADL and was discharged. However, he lost approximately 9% of his body weight at discharge. In addition, his hand grip strength and six-minute walking distance were lower and shorter than the reference values, respectively. His mental component summary of the Short Form-8 was lower than the national standard deviation for the Japanese population. Conclusion: Although survivors of severe COVID-19 who undergo early rehabilitation can be discharged from an acute care hospital, they may have several impairments in their physical and mental status, including muscle function, diffusion capacity, exercise tolerance, and health-related quality of life.

Key words: SARS-CoV-2, COVID-19, Early mobilization, Rehabilitation, Post-ICU syndrome

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), a new coronavirus that emerged in 2019, causes coronavirus disease 2019 (COVID-19)². Although approximately 5% of COVID-19 patients who are admitted to the intensive care unit (ICU) require advanced critical care such as mechanical ventilation support or extracorporeal membrane oxygenation³, the mortality among patients admitted to the ICU ranges from 39% to 72%⁴.

However, even if these patients survive, survivors of severe COVID-19 are thought to experience complications such as severe respiratory dysfunction, ICU-acquired weakness, and delirium⁵. Therefore, World Health Organization (WHO)⁶ recommends that early mobilization and rehabilitation interventions should be provided when it is safe to do so.

The clinical course of oxygenation, physical function, cognitive function, and activities of daily living (ADL) in survivors of severe COVID-19 who underwent early rehabilitation have not been well described. Even if they have a good clinical course, recovery of their physical and mental status at discharge from the acute care hospital may be in-
adequate. However, it has not been clarified enough to understand the impairments after COVID-19 recovery.

We encountered a case of severe COVID-19 in which the patient underwent early rehabilitation in the ICU. We report on the course of his physical function and mental status and present the problems that a survivor of severe COVID-19 may have at discharge from an acute care hospital.

Case Presentation

A 62-year-old man (body mass index: 27.4 kg/m\(^2\)) was admitted to our emergency department in early April 2020 with severe acute respiratory infection. He had some risk factors for developing severe COVID-19, such as being male and having at least one co-existing comorbidity (hypertension/diabetes)\(^1\). Patient tested positive for SARS-CoV-2 by reverse-transcriptase polymerase chain reaction. Then, he was intubated and placed on a mechanical ventilator. After admission to the negative-pressure room in the ICU, the patient was provided with deep sedation using of vecuronium, a neuromuscular blocking agent, for the first 48 hours to prevent ventilator-induced lung injury, which could occur if a patient exerts strong spontaneous respiratory efforts and has continuous refractory hypoxemia. He was managed with high positive end-expiratory pressure ventilation (PEEP) and lung-protective ventilation according to the treatment guidelines\(^7\) of acute respiratory distress syndrome (with plateau pressure less than or equal to 30 cm H\(_2\)O and tidal volumes based on the patient’s height). In addition, favipiravir and azithromycin were administered for compassionate use for 14 days.

The treatment and rehabilitation courses during the ICU stay are shown in Fig. 1. On day 4 of ICU admission, PEEP decreased as the P/F ratio improved to 304, and sedation was reduced to initiate a daily awake. On day 7, rehabilitation was started to improve physical function and prevent post-intensive care syndrome (PICS). However, as the sedative was reduced, the patient became agitated, and the P/F ratio decreased to <100; hence, midazolam was used in addition to propofol. On day 9, propofol was discontinued due to elevated creatinine kinase and suspected propofol-infusion syndrome, which is a potential risk factor for hypercoagulation. Therefore, rehabilitation from day 7 to day 10 consisted of a range of motion exercises and positioning by a physiotherapist. The physiotherapist who provided rehabilitation to patients with COVID-19 had specialized knowledge and skills with previous ICU experience and was trained in appropriate donning and doffing of personal protective equipment (PPE). Whenever the patient undergoes exercise and rehabilitation, the attending physiotherapist and other staff entering the negative-pressure room used full PPE (isolation gown, gloves, N95 mask, hair cap, and face shield to protect the eyes).

We stopped sedation and resumed daily awake on day 10. The next day, the patient was able to follow orders from the medical staff, and his status (clinical presentation, respiratory, and hemodynamic function) was stable, so the mobilization program was started actively. Mobilization was performed in serial stages of sitting, standing, and stepping with doctors, nurses, and the physiotherapist wearing full PPE (Fig. 2) from day 11 to day 16 (approximately 30 min/day). We performed the first physical function (Medical Research Council Sum Score; MRC-SS) and mental health (Confusion assessment method for the intensive care unit [CAM-ICU]) assessment on day 11 of ICU admission. In the initial stage, the patient had significant muscle weakness and was cognitively impaired. In addition, the functional status score for the ICU (FSS-ICU), which is a 5-item and 35-point assessment of movement on a bed, transfers, and ambulation designed for ICU patients, was very low (5 points). The patient required assistance in all his movements during the ICU stay. The spontaneous breathing trial began on day 14, and the patient was successfully extubated the next day. He was discharged from the ICU on day 16. His hemodynamic status remained stable (mean arterial pressure >65 mmHg) during the ICU stay, and he had no other signs of organ failure, such as acute kidney injury or acute liver injury.

After ICU discharge, the patient was managed in a dedicated COVID-19 ward, and his activity was still restricted due to the risk of infecting other patients. Rehabilitation was continued with full PPE and direct intervention once a day after ICU discharge. Then, we gave him an exercise pamphlet prepared by physiotherapists to encourage self-training. After discharge from the ICU, his muscle strength and cognitive function gradually improved. The MRC-SS increased to more than 48 points on day 22, and his disorientation improved on day 24. It took the patient 21 days from ICU admission for bed mobility and transfer to become independent of medical staff, and 31 days to regain ambulation in his room. On day 37 after admission, the patient was discharged home after confirmation with two negative PCR results. Prior to discharge, the patient’s physical function and mental health status were evaluated.

Physical Function and Mental Health Status at Discharge

The patient’s physical function and mental health status at the time of discharge are shown in Table 1. Disability in performing basic ADL was assessed by the functional independence measure (FIM) score at discharge; FIM score was 126 points, indicating functional independence in the motor and cognitive domains. However, body composition decreased slightly: his body weight decreased by 7.2 kg from admission, and body mass index decreased from 27.4 kg/m\(^2\) to 25.1 kg/m\(^2\). Muscle strength was assessed us-
Fig. 1. Treatment and rehabilitation course during intensive care unit stay

*: intubated

A/C, Assist/Control; SPONT, Spontaneous; AP, inspiratory positive airway pressure above PEEP; PS, pressure support; PEEP, positive end-expiratory pressure; PaO₂, partial pressure of arterial oxygen; FiO₂, fraction of inspiratory oxygen; RASS, Richmond Agitation-Sedation Scale; GCS, Glasgow Coma Scale; BPS, Behavioral Pain Scale; CAM-ICU, Confusion assessment method for the intensive care unit; MRC-SS, Medical Research Council Sum Score; FSS-ICU, Functional status score for the intensive care unit; ROM, range of motion; MST, muscle strengthening training.

Fig. 2. Active mobilization with medical staff wearing full personal protective equipment in a negative-pressure room
which is a screening tool for depression, the patient scored 3 points. In addition, he was anxious about his life and returned to work after discharge from the hospital.

**Discussion**

The patient was a survivor of severe COVID-19 and underwent early mobilization and rehabilitation in the ICU. Although he developed ICU-AW and delirium due to muscle relaxation, prolonged immobility, and other factors associated with the ICU situation, his muscle weakness and cognitive function gradually improved. Finally, the patient attained independence in performing basic ADL and was discharged. However, he had several impairments in physical function and mental health at discharge.

First, the patient had skeletal muscle dysfunction due to reduced skeletal muscle mass and muscle strength. He lost approximately 9% of his body weight during his 37-day hospital stay. In addition, both calf and arm circumferences decreased compared to those at the initial assessment. Weight loss is strongly associated with total-body bone-free lean mass in older adults. These results suggest a decrease in muscle mass during the hospital stay. Handgrip strength in this patient was lower than the reference value for the Japanese community-dwelling elderly population. The quadriceps isometric strength (% body weight) was 48.4% and was considered to be low compared with the best predictive cutoff for an estimated five metabolically-equivalent exercise capacity levels in patients with coronary artery disease. These changes may have occurred due to severe inflammation secondary to COVID-19, which causes protein catabolism. Having limited activity in the hospital might have contributed too. Survivors of acute respiratory distress syndrome who presents with severe inflammation have been reported to have significant impairment in skeletal muscle function for six months to two years after discharge from the ICU. Similarly, survivors of severe COVID-19 may require longer time to recover skeletal muscle function.

Second, his 6MWD was lower than the estimated reference value obtained from the healthy subset, and he had remained a significant decrease in SpO₂ on effort. Mo et al. revealed abnormalities in pulmonary function in COVID-19 patients when they performed spirometry and pulmonary diffusion capacity tests at discharge. Impairment of diffusion capacity was the most common abnormality in pulmonary function; an anomaly was noted in diffusion capacity of the lungs for carbon monoxide (DLCO) in 47.2%

**Table 1. Result of rehabilitation assessment at time of home discharge**

<table>
<thead>
<tr>
<th>Outcome measure</th>
<th>Assessment tool</th>
<th>Value (on admission to hospital)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body composition</td>
<td>Body weight</td>
<td>76.8 kg (84 kg)</td>
</tr>
<tr>
<td></td>
<td>Body mass index</td>
<td>25.1 kg/m² (27.4 kg/m²)</td>
</tr>
<tr>
<td></td>
<td>Calf circumference</td>
<td>34.0 cm (35.0 cm)</td>
</tr>
<tr>
<td></td>
<td>Arm circumference</td>
<td>32.5 cm (34.0 cm)</td>
</tr>
<tr>
<td></td>
<td>Triceps skinfolds</td>
<td>1.3 cm</td>
</tr>
<tr>
<td>Muscle strength</td>
<td>Hand grip strength (Rt.)/(Lt.)</td>
<td>29.9/30.8 kgf</td>
</tr>
<tr>
<td></td>
<td>Quadriceps isometric strength (Rt.)/(Lt.)</td>
<td>34.1/40.2 kgf</td>
</tr>
<tr>
<td>Balance function</td>
<td>Berg balance scale</td>
<td>56 points</td>
</tr>
<tr>
<td>Physical performance</td>
<td>SPPB total score</td>
<td>11 points</td>
</tr>
<tr>
<td></td>
<td>-Balance score</td>
<td>4 points</td>
</tr>
<tr>
<td></td>
<td>-Gait speed score</td>
<td>4 points: 4.42 sec</td>
</tr>
<tr>
<td></td>
<td>-Standing chair score</td>
<td>3 points: 13.64 sec</td>
</tr>
<tr>
<td>Activities of daily living</td>
<td>FIM total score</td>
<td>126 points</td>
</tr>
<tr>
<td></td>
<td>-Motor subtotal score</td>
<td>91 points</td>
</tr>
<tr>
<td></td>
<td>-Cognitive subtotal score</td>
<td>35 points</td>
</tr>
<tr>
<td>Exercise tolerance</td>
<td>6-minute walk test (room air)</td>
<td>425 m</td>
</tr>
<tr>
<td></td>
<td>Distance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SpO₂ (pre) → (post)</td>
<td>96 → 92 %</td>
</tr>
<tr>
<td></td>
<td>Pulse rate (pre) → (post)</td>
<td>96 → 134 bpm</td>
</tr>
<tr>
<td></td>
<td>Respiratory rate (pre) → (post)</td>
<td>20 → 28/min</td>
</tr>
<tr>
<td></td>
<td>Rate of perceived exertion (pre)</td>
<td>chest: 3/leg: 0.5</td>
</tr>
<tr>
<td>Health-related quality of life</td>
<td>SF-8 physical component summary</td>
<td>48.4</td>
</tr>
<tr>
<td></td>
<td>SF-8 mental component summary</td>
<td>39.4</td>
</tr>
<tr>
<td>Depression symptom</td>
<td>Geriatric depression scale-5</td>
<td>3 points</td>
</tr>
</tbody>
</table>

SPPB, short physical performance battery; FIM, functional independence measure; SpO₂, oxygen saturation of peripheral artery; SF-8, Short Form -8.
of all cases. Although in this case we could not assess spirometry and pulmonary diffusion capacity before discharge, it is possible that there was a decline in DLCO, as seen in these reports. SARS is an acute, severe, lower respiratory tract illness caused by infection with SARS coronavirus that spread worldwide during 2002-2003\(^{3,4}\). A cohort study of a selected SARS survivor showed significant impairment of DLCO and lowered exercise tolerance compared to that in the healthy controls of the same age groups at 24 months post-illness\(^{5,6}\). In particular, the severe cases that required intubation after admission to the ICU had a significantly lower DLCO than non-intubated patients at 24 months post-illness. These findings suggest that the diffusion capacity and exercise tolerance may decline and persist for a long time in patients with severe COVID-19.

Third, with regard to mental health, there was a marked decrease in MCS on the SF-8\(^{7}\). The GDS-5 score was also above 2 points, which is the cutoff score for screening for depression\(^{16}\). These results suggest depression in health-related quality of life (QOL). This depression at discharge may pertain to his anxiety regarding his life after discharge and returning to work. In addition, the decline in physical function may also be associated with an impaired health-related QOL. A prospective cohort study of SARS showed that the patient’s SF-36\(^{7}\) was lower than that of the healthy population throughout the study. Moreover, 29.6% of the healthcare workers (HCW) and 7.1% of non-HCWs who survived SARS did not return to work for two years after illness onset\(^15\). Mental health appears to be a common problem in COVID-19 patients, and long-term follow-up is necessary.

These findings indicate that survivors of severe COVID-19 show improvement in ADL and acute respiratory symptoms; however, they still have impairments in physical function and mental health at discharge. Although the majority of COVID-19 patients do not require ICU admission, we should note that patients who received intensive care and required ventilators may be discharged with several impairments. Recently, the lasting symptom burden after COVID-19 recovery, such as chronic cough, shortness of breath, chest tightness, cognitive dysfunction, and extreme fatigue, have been reported\(^{17,18}\). These symptoms have persisted for six months after acute infection\(^{19}\) and have come to be known as “long COVID” or “post-COVID-19 syndrome”\(^{20}\). Although there have been no follow-up studies of patients with severe COVID-19 exclusively, these patients may have more impairments, as in this case.

A previous study involving a 6-week respiratory rehabilitation training program for elderly patients with COVID-19 after discharge showed that it improved respiratory function, exercise tolerance, and QOL\(^{21}\). At present, our hospital and many hospitals in Japan have not yet established a system to provide outpatient rehabilitation for survivors of COVID-19. Physical therapists should carefully assess COVID-19 inpatients, especially those with severe COVId-19, not only for the return of ADLs to healthy levels but also for lasting impairment in disease-specific physical function and mental status. In addition, a system that can provide continuous rehabilitation and assessment for survivors of severe COVID-19 affected with muscle atrophy, exercise intolerance, and lower QOL should be considered necessary in the future.

**Conclusion**

We reported physical function and mental health status at the time of discharge in a patient with severe COVID-19 in Japan, in addition to the course of rehabilitation. After discharge, several impairments were evident in the patient’s physical and mental status, such as muscle function, diffusion capacity, exercise tolerance, and health-related QOL.

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**Conflict of Interest**: The authors declare that they have no competing interests.

**Informed consent and patient details**: Written informed consent was obtained from the patient for publication of the anonymized case details and images.

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