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Original Article

Age and period of ventilator use are related to walking independence at the time of discharge in patients with severe COVID-19 pneumonia: a single-center retrospective observational study

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Abstract. [Purpose] This study aimed to identify the factors and cutoffs associated with walking independence in patients with severe COVID-19 pneumonia. [Participants and Methods] In total, 112 patients with COVID-19 pneumonia (98 males and 14 females) who were hospitalized between March 2020 and August 2021 and underwent physiotherapy during mechanical ventilation were included in the study. Attributes, respiratory function, physical function, and bed-withdrawal status were compared between two groups of patients, who were classified according to their ability to walk independently at discharge. The independent variables were reduced to four components by principal component analysis. Logistic regression analysis was performed with walking independence at discharge as the dependent variable. Receiver operating characteristic curves for the extracted factors were drawn, and cutoff values were calculated. [Results] At discharge, 76 patients were able to walk independently, while 36 were not. The logistic regression analysis was adjusted according to age and mechanical ventilation time. Cutoffs were an age of 56 years and a ventilation period of 7.5 days. [Conclusion] In cases of patients with severe COVID-19 pneumonia who required ventilators, age and mechanical ventilation time were associated with ambulatory independence at discharge, indicating the importance of reducing the ventilation period by providing respiratory physiotherapy, including expectoration, positioning, and weaning.
Key words: Severe COVID-19 pneumonia, Age, Ventilation period

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INTRODUCTION

The novel coronavirus infectious disease that emerged in 2019 (COVID-19) developed into a global pandemic, with droplet transmission being one of the routes of infection. Among those affected, a certain number of patients develop severe cases. The causes contributing to the severity of COVID-19 are currently the subject of many studies; however, the precise mechanism of severe COVID-19 remains to be elucidated. A review of past studies has reported that severely ill patients are typically admitted to the intensive care unit (ICU) at 7 to 10 days after symptom onset[1)]. Severe cases of COVID-19 have a

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similar clinical picture to that of acute respiratory distress syndrome (ARDS), albeit with minor differences. ARDS secondary to COVID-19 is associated with accelerated proliferation of fibroblasts and myofibroblasts, resulting in airborne infection[2] and fibrosis of the lungs[3]. It is also complicated by a decreased adaptive immune response due to delayed activation of lymphocytes[4] and coagulation disorders such as thrombus formation and hemorrhage in intrapulmonary microvessels[5], leading to a state of increased systemic inflammation in addition to pulmonary disease.

In the management of critically ill patients, the ventilator management in the ICU frequently represents a pivotal therapeutic strategy. As a result, patients on ventilators develop post-intensive care syndrome (PICS) not only from their primary illnesses but also from various complications and the unfamiliar environment of the ICU. In addition, some patients require assistance with standing and walking at the time of discharge from hospital. PICS is defined as impairments in motor, cognitive, and mental functions that occur after ICU admission or discharge. Some reports have shown that any cognitive decline that may develop after admission to the ICU is associated with ICU-acquired weakness (ICU-AW)[6, 7]. Bienvenu et al. reported that, in a 2 year prospective observational study on acute lung injury patients discharged from the ICU, 40% of their patients demonstrated depressive symptoms at follow-up assessments[8]. These reports indicate that prevention of PICS is essential. However, a significant proportion of patients are still discharged with compromised physical functionality attributed to lingering symptoms.

Despite reports associating COVID-19 with systemic inflammation and ARDS, and observed declines in activities of daily living (ADL) due to PICS in some instances, no studies have yet examined the factors associated with these conditions in patients with severe COVID-19. In addition, there are only scattered reports on patients admitted for severe COVID-19, who had not previously required mobility aids but developed conditions that necessitated assistance, or even became entirely non-ambulatory following their intensive care treatment. In the present study, we aimed to identify the factors and cutoff points that correlate with capability or incapability of independent ambulation at the time of discharge from hospital following recovery from severe COVID-19 pneumonia.

PARTICIPANTS AND METHODS

Patients with a diagnosis of COVID-19 who had been admitted to our hospital between March 2020 and August 2021, had been independent in ADL before admission, and had received physical therapy during hospitalization were included in the present study if they were aged 18 years or older at the time of admission. Of the 157 patients, 112 met the inclusion criteria. The excluded patients were: 26 who had not received ventilatory management; 18 who died during hospitalization; and one with missing data.

The patients' physical characteristics (age, sex, height, weight, and body mass index [BMI]) and medical history (diabetes mellitus [DM], hypertension [HT], chronic heart failure [CHF], chronic kidney disease [CKD]) were obtained from their medical records before and during hospitalization. The results of blood biochemical tests such as white blood cell (WBC) count, C-reactive protein (CRP), and ferritin were collected to determine illness severity. At our hospital, Sequential Organ Failure Assessment (SOFA) scores are collected for all patients admitted in the emergency center as triage to determine illness severity. The SOFA scores of the study participants were also collected on admission, and the disease severity was determined.

The target group consisted of 76 patients with a Functional Status Score for ICU (FSS-ICU) of 7 (total independence) for ambulation at the time of discharge, and was named the "independent group". The control group consisted of 36 patients whose FSS-ICU scores ranged from 0 (unable to perform) to 6 (moderate independence) and was named the "non-independent group". All patients could walk without a cane or other walking aids prior to admission. Therefore, all those with an FSS-ICU score lower than 7 were classified as controls (Fig. 1).

Rehabilitation was performed in accordance with a rehabilitation program for patients with respiratory failure standardized by the expert consensus of the Japanese Society of Intensive Care Medicine[9]. During the ICU stay, the conditioning regimen focused on postural drainage and respiratory assistance; after leaving the ICU, the patients underwent strength training, ADL training, and endurance training to improve their activity level. Continuous renal replacement therapy (CRRT), venous extracorporeal membrane oxygenation (VV-ECMO), and insertion of central venous catheters were also performed, all of which may have contributed to delirium recall and were the factors to delay bed release. These data were collected from the patients' medical records.

The ventilatory mechanics of the patients were monitored and assessed using the HAMILTON-G5 (HAMILTON MEDICAL, Bonaduz, Switzerland). Respiratory status was measured with the patient in the supine position 10 minutes after tracheal intubation, and peak pressure (Ppeak), plateau pressure (Pplat), end-expiratory positive pressure (PEEP), static lung compliance (Cstat), driving pressure (ΔP), tidal volume (Vt), ventilation volume (VR) and minute volume (MV) were measured when the patient's respiratory status was stable. The measurement conditions were: volume-controlled ventilation (VCV) as the ventilation mode; square wave as the inspiratory flow velocity waveform; and 0.3 to 0.5 seconds as the expiratory end pause time.

ICU-AW and PICS were assessed by Medical Research Council sum score (MRCS), and ADL ability was assessed by FSS-ICU at the beginning and end of the physical therapy course.

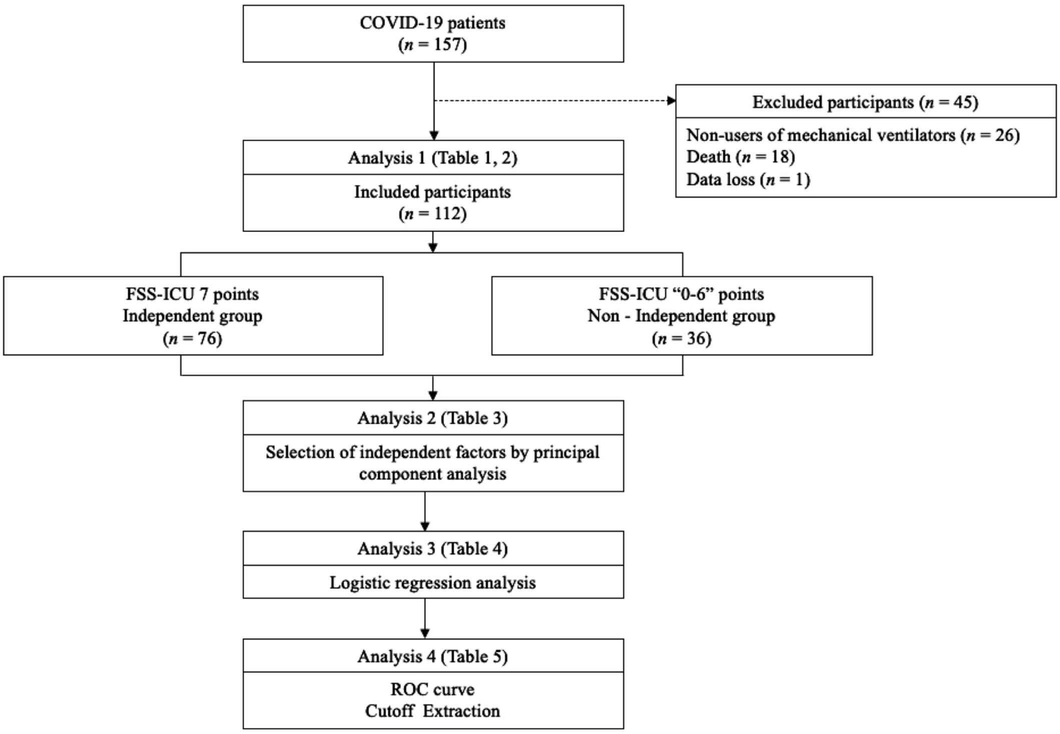

Fig. 1. Flowchart of participant selection.

The following data were collected: period from hospital admission to the start of physical therapy; intervention time for physical therapy; overall length of stay in hospital; length of stay in the ICU; and period of ventilator use. In addition, the durations (days) from admission to the first occurrence of sitting, standing, and walking were collected as an index of the effectiveness of the physical therapy intervention. The presence or absence of adverse events associated with physical therapy, including reintubation, pulmonary thromboembolism, falls, and self-extubation, was also evaluated.

Prior to each test, a comparison between the independent and non-independent groups was conducted as a preliminary study. The median and interquartile range (first to third quartiles) and mean ± standard deviation of each measurement were calculated as descriptive statistics. The patient characteristics (age, height, weight, BMI, WBC, CRP, ferritin, and SOFA scores) were compared between the groups with an unpaired t-test.

Fisher's exact probability test was performed to assess the presence or absence of a history of chronic heart failure and chronic renal failure, as well as environmental factors such as CRRT, VV-ECMO, and CVC. Pearson's χ^2 test was performed to assess a history of DM and HT and occurrence of delirium and reinsertion. Non-correspondence t-tests were performed to assess Ppeak, PEEP, ΔP, Cstat, or PaO2/FIO2 ratio (P/F ratio) for ventilator settings. The Mann–Whitney U-test was used to assess the MRCS and FSS-ICU scores, which assess physical function and activity capacity, respectively.

A t-test without correspondence was performed for the durations from admission to the start of physical therapy and the start of early mobilization therapy, period of ventilator use, duration of ICU stay, duration of hospital stay, duration of physical therapy intervention, and durations from admission to sitting, standing, and walking.

Next, 16 out of 20 items that showed significant differences in each test, excluding nominal scales, were examined by principal component analysis.

Multiple logistic regression analysis was conducted after decreasing variables by likelihood ratio test, with the factors that showed significant differences in each test as the independent variables and the ability to walk at the time of discharge as the dependent variable in each component in the principal component analysis. Receiver operating characteristic (ROC) analysis was also performed using the items selected in the multiple logistic regression analysis, and the areas under the curve (AUC) and cutoffs were determined. The cutoff was calculated using the Youden Index (sensitivity + specificity − 1), and defined as the point with the highest Youden Index value. Statistical processing was performed using IBM SPSS Statistics ver. 23.0 (IBM, Armonk, NY, USA) with a significance level of 5%. This manuscript has not been published or presented elsewhere in part or in entirety, and is not under consideration by another journal. This study was approved by the Ethics Review Committee of Japanese Red Cross Medical Center (approval number: 1396) and is in compliance with the Declaration of Helsinki. Information about opt-out was provided on the Japanese Red Cross Medical Center website.

RESULTS

The analysis included 112 patients, with 76 in the independent group and 36 in the non-independent group. The χ^2 test, Fisher's exact probability test, and either Student's t-test or the Mann–Whitney U-test were performed to compare patient background, ventilator settings motor function, and in- and out-of-bed status between the two groups (Tables 1, 2).

There were significant differences regarding patient background (age, height, body weight, DM, presence or absence of delirium, SOFA score, and Ferritin) while the differences regarding ventilator settings were not statistically significant.

Significant differences were also found in physical function and activity capacity, specifically in MRCS upper limbs, FSS-ICU rolling, and FSS-ICU ambulation at the initial evaluation. At the final evaluation, all MRCS and FSS-ICU scores showed significant differences. The two factors related to in- and out-of-bed status, namely the time from admission to the start of walking and the duration of ventilator use, also differed significantly.

The results of the principal component analysis are shown in Table 3. These results were classified into four components: component 1 was defined as basic movement ability and physical function at the time of the final evaluation; component 2 was basic movement ability and physical function at the time of the initial evaluation; component 3 was patient background in terms of age and severity of illness; and component 4 was devices and blood biochemistry tests. After component extraction, the cumulative contribution ratio was calculated to be 75.6%, which is within the range typically used to determine principal components.

Table 1. Patient characteristics

	Independent group (n=76)	Non-independent group (n=36)
Age (years)***	55.8 ± 12.3	66.7 ± 13.0
Sex (male: female)	69:7	29:7
Height (cm)**	169.6 ± 7.48	165.2 ± 9.51
Body weight (kg)*	72.8 ± 19.9	67.4 ± 17.4
BMI (kg/m^2)	25.0 ± 17.5	24.5 ± 5.14
Diabetes mellitus (n)***	14	15
Hypertension (n)	28	17
Chronic heart failure (n)	1	1
Chronic kidney disease (n)	3	3
CRRT (n)	3	5
VV-ECMO (n)	2	4
CVC (n)	10	5
Delirium (n)*	12	12
Reintubation (n)	6	2
SOFA score (points)*	7 (6–9)	8 (7–10)
CRP (mg/dL)	12.2 ± 7.58	10.6 ± 7.67
WBC (μL)	7,966.5 ± 3,260.3	8,511.9 ± 4,649.9
Ferritin (ng/mL)**	1,813.0 ± 1,818.1	1,168.5 ± 810.4
Cstat (ml/cmH$_2$O)	37.8 ± 1.57	33.1 ± 263
Driving pressure (cmH$_2$O)	12.1 ± 3.33	11.8 ± 3.65
P/F ratio	273.9 ± 73.7	178.2 ± 8.51
PEEP (cmH$_2$O)	12.1 ± 0.38	11.8 ± 0.61
Ppeak (cmH$_2$O)	26.0 ± 0.51	26.6 ± 0.93

The disease background, medical history, and respiratory function of the independent and non-independent groups were compared.
p-value (*p<0.05, **p<0.01, ***p<0.001).
Patients background, independent t-test (average ± standard deviation).
Medical history Pearson's χ^2 test and Fisher's exact test.
Presence of, Pearson's χ^2 test.
Patient severity, Pearson's χ^2 test (Median [minimum value–maximum value]).
Biochemical examination, Independent t-test (average ± standard deviation).
Artificial ventilator mode, Independent t-test (average ± standard deviation).
BMI: body mass index; CRRT: continuous renal replacement therapy, CVC: central venous catheter, VV-ECMO: veno-venous extracorporeal membrane oxygenation, Peak: peak pressure, PEEP: positive end-expiratory pressure, driving pressure (ΔP), Cstat: static lung compliance, P/F ratio: PaO_2/FIO_2

Table 2. Comparison of characteristics, respiratory function, physical function and in or out-of-bed status between the independent group and non-independent groups

	Independent group (n=76)	Non-independent group (n=36)
Initial Upper limbs (points)*	15 (0–24)	0 (0–18)
Initial Lower limbs (points)	17 (0–24)	0 (0–23)
Initial Total Score (points)	32 (0–49)	0 (0–41)
Initial Rolling (points)*	2 (1–5)	1 (1–2)
Initial Supine-to-sit transfer (points)	1 (0–4)	1 (1–1)
Initial Unsupported sitting (points)	1 (0–5)	1 (0–2)
Initial Sit-to-stand transfer (points)	0 (0–3)	0 (0–0)
Initial Ambulation (points)*	0 (0–0)	0 (0–0)
Initial Total score (points)	3 (2–17)	3 (2–7)
Final Upper limbs (points)***	30 (30–30)	24 (18–24)
Final Lower limbs (points)	30 (30–30)	24 (24–28)
Final Total score (points)***	60 (60–60)	48 (42–54)
Final Rolling (points)***	7 (7–7)	7 (6–7)
Final Supine-to-sit transfer (points)***	7 (7–7)	7 (5–7)
Final Unsupported sitting (points)***	7 (7–7)	7 (5–7)
Final Sit-to-stand transfer (points)***	7 (7–7)	5 (4–6)
Final Ambulation (points)***	7 (7–7)	5 (0–6)
Final Total score (points)***	35 (35–35)	30 (21–33)
E-ICU stay (days)	7.52 ± 5.08	9.50 ± 5.97
Ventilator usage period (days)*	6.10 ± 3.41	11.1 ± 12.8
Intervention time for EM (days)	15.2 ± 10.2	21.6 ± 21.4
Hospital stay (days)	19.8 ± 8.81	27.2 ± 23.9
Period from start to EM (days)	3.93 ± 2.86	4.39 ± 5.70
Start to sitting position (days)	1.40 ± 2.26	2.52 ± 3.57
Start to standing position (days)	3.25 ± 3.84	7.14 ± 12.4
Start to walking (days)***	5.92 ± 5.85	16.0 ± 15.1

p-value (*p<0.05, **p<0.01, ***p<0.001).
Initial MRCS, Initial FSS-ICU, Final MRCS, Final time FSS-ICU, Mann–Whitney U test (Median [minimum value–maximum value]).
Length of stay or period, Independent t-test (average ± standard deviation).
Medical Research Council-sum score (MRCS): Upper limbs or Lower limbs, range 0–30, total score range 0–60.
Functional Status Score for the ICU (FSS-ICU): Rolling, Supine-to-sit transfer, Unsupported sitting, Sit-to-stand transfer, Ambulation, range 0–7, total score range from 0–35.
E-ICU: emergency ICU; EM: early mobilization.
Physical therapy in the ICU was provided 5 days a week, 40 minutes per session, for a total of 200 minutes per week.
In- or out-of-bed status indicates the number of days from admission to the start of EM, sitting position, standing position, and walking.

The results of the multiple logistic regression analysis for walking independence are presented in Table 4. Multicollinearity was taken into account in choosing independent factors to be included in the analysis, and one item from each of the four components based on the results of the principal component analysis was selected. The four independent variables were age, MRCS upper limbs, FSS-ICU rolling, and ventilator usage period. In the present study, a backward stepwise method with likelihood ratios was employed for the purpose of calculating factors related to independent walking in COVID-19 patients using various items, since there have been few studies reporting on this subject to date.

The results showed that age (β 0.06, SE 0.02, Ex[B]1.06, 95% CI 1.030–1.113, p=0.00), and ventilator usage period (β 0.09, SE 0.04, Ex[B]1.10, 95% CI 1.004–1.22, p=0.04) were selected. The result of Hosmer–Lemeshow's test showed p=0.92, which is acceptable. The percentage of correct classifications was 78.6%, which is considered appropriate.

The results of the roc analysis are shown in Table 5, as well as roc curves of age for independent walking (Fig. 2). the cutoff value for age was 56 years old (sensitivity 0.833, specificity 0.533, auc 0.725, p=0.00) and roc curves of ventilator usage period for independent walking (Fig. 3). the cutoff value for the ventilator usage period was 7.5 days (sensitivity 0.500, specificity 0.273, auc 0.633, p=0.02). after the roc analysis, the cutoffs for these two items were selected in the multiple logistic regression analysis.

Table 3. Selection of independent factors by principal component analysis

	Components 1	Components 2	Components 3	Components 4
Final FSS-ICU Total score	0.966	−0.170	0.123	−0.041
Final FSS-ICU Sit-to-stand transfer	0.959	−0.102	0.048	−0.044
Final MRCS Total score	0.950	−0.001	−0.083	−0.005
Final FSS-ICU Unsupported sitting	0.933	−0.197	0.128	−0.048
Final MRCS Lower limbs	0.929	0.020	−0.089	−0.067
Final FSS-ICU Supine-to-sit transfer	0.927	−0.180	0.126	−0.032
Final MRCS Upper limbs	0.916	−0.021	−0.073	0.051
Final FSS-ICU Rolling	0.897	−0.186	0.124	−0.018
Final FSS-ICU Ambulation	0.837	−0.147	0.143	−0.044
Initial MRCS Upper limbs	0.310	0.779	0.284	0.145
Initial FSS-ICU Rolling	0.309	0.777	0.377	0.205
Initial FSS-ICU Ambulation	0.180	0.551	0.367	0.184
SOFA score	−0.167	−0.441	0.341	0.395
Age	−0.336	−0.276	0.587	−0.032
Ventilator usage period	−0.162	−0.547	0.031	0.395
Ferritin	0.178	−0.106	−0.099	0.738

Each grouping of the principal component analysis is described in components1–4.
One independent factor was extracted from components1–4 to feed into the logistic regression analysis.
FSS-ICU: functional status score for the intensive care unit; MRCS: medical research council sum score; SOFA: sequential organ failure assessment.

Table 4. Multiple logistic regression analysis for walking independence

	β	SE	Odds ratio	95% CI
Final MRCS Upper limbs	0.21	0.21	1.02	0.972–1.074
Initial FSS-ICU Rolling	−0.160	0.12	0.85	0.678–1.071
Age***	0.06	0.02	1.06	1.030–1.113
Ventilator usage period*	0.09	0.04	1.10	1.004–1.202

p-value (* $p<0.05$, ** $p<0.01$, *** $p<0.001$)
β: Standard partial regression coefficient; SE: Standard Error; 95% CI: Confidence interval;
Hosmer–Lemeshow's test, p=0.926; Percentage of correct classification, 78.6%.
MRCS: medical research council sum score; FSS-ICU: functional status score for the intensive care unit.

Table 5. Receiver operating characteristic curve analysis of age and ventilator usage period

	Cutoff	Sensitivity	Specificity	AUC	95% CI
Age***	56 years	83.30%	55.30%	0.725	0.623–0.827
Ventilator usage period*	7.5 day	50.00%	23.70%	0.633	0.518–0.749

p-value (* $p<0.05$, ** $p<0.01$, *** $p<0.001$).
AUC: area under the curve; 95% CI: confidence interval.

DISCUSSION

The purpose of the present study was to determine the factors and cutoffs associated with independent walking at discharge from hospital in patients with severe COVID-19 pneumonia. As a result, age and duration of ventilator use were extracted as independent factors to predict whether patients would be ambulatory without assistance at discharge.

The cutoffs were 56 years for age and 7.5 days for ventilator usage period. From the findings of this study, we deduce that diverse and complexly interrelated factors may be involved in patients' ability of independent walking at the time of hospital discharge. Therefore, further detailed examinations of these findings are required.

Age[10] has previously been reported as a contributing factor to COVID-19 severity. In our study, the mean age of the independent group was 55.8 years, while that of the non-independent group was 66.7 years. The comparison of the two groups also suggest that the presence of DM[11–13] in a patient's medical history and its effect are associated with severe

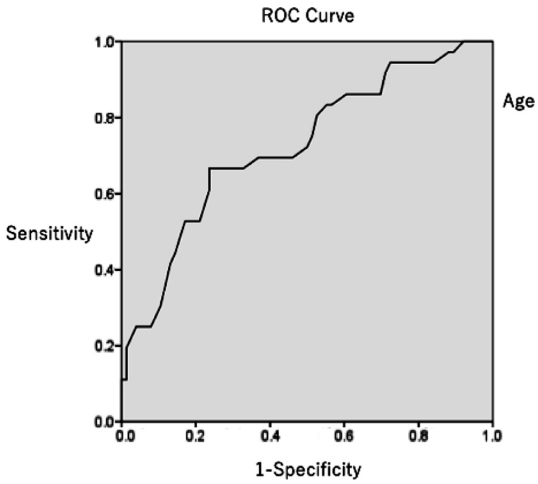

Fig. 2. Receiver operating characteristic (ROC) age.

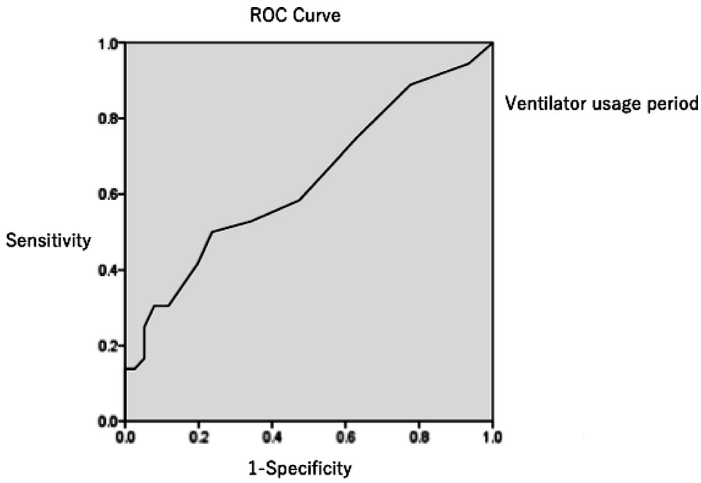

Fig. 3. Receiver operating characteristic (ROC) ventilator usage period.

COVID-19 pneumonia. Study results suggest that aging and DM are factors in the severity of disease[11–13] and may contribute to the decline in the ability to walk. In the present study, all patients had severe cases of COVID-19, and were on ventilators. However, some of these patients were able to walk independently at the time of discharge despite their disease severity being similar. Logistic regression analysis also revealed a significant difference in SOFA scores at ICU admission between the independent and non-independent groups (Table 1), but the principal component analysis results showed only a weak association between SOFA score and the ability to walk independently (Table 3). Therefore, the effect of complications as associated with ICU-AW, prolonged bed rest, and deep sedation, rather than illness severity, may have had a greater influence on the ability of patients to walk independently at the time of discharge. In addition, as patients age, the risk of complications generally increases, and bed rest duration tends to lengthen. Prolonged bed rest reportedly causes rapid skeletal muscle atrophy due to catabolic effects in critically ill patients[14]. In particular, severe COVID-19 pneumonia leads to systemic hyperinflammation and hypercytokinemia. Elevated blood concentrations of cytokines can injure vascular endothelial cells, leading to multiple organ failure. This suggests that multi-organ failure and prolonged bed rest associated with a state of systemic hyperinflammation may evoke skeletal muscle atrophy, and that the resulting ICU-AW and decreased activity may likely affect the patient's ability to walk at the time of discharge.

Regarding the ventilator usage period, the number of days that was considered to have affected the ability to walk independently at discharge was 7.5 days. In the United States, it has been reported that 50–70% of five million patients undergoing intensive care will develop PICS[15], which reportedly starts to develop as early as two days after ICU admission[16]. It has also been reported that 33% of ventilator-controlled patients develop ICU-AW[15]. Other studies have reported that long-term ventilator use increases the risk of ventilator-associated pneumonia (VAP) and is a factor associated with significant systemic effects, including a high rate of dysphagia in critically ill patients in the ICU[17], and that dysphagia is associated with a high incidence of VAP, reintubation, prolonged hospital stay, inability to eat or drink, and poor prognosis, including in-hospital mortality[18].

Rehabilitation in the ICU is considered very important to shorten the period of ventilator use. Some reports have shown that rehabilitation on PICS and ICU-AW reduced delirium and improved ICU-AW[19, 20], and may promote ventilator weaning[21].

Physical therapy is likely to contribute to shortening the period of ventilator use. Moreover, airway clearance techniques, such as early mobilization (EM), positional drainage, and expectoration, have been shown to be effective. Schweickert and Dong reported shorter ventilator use periods as an effect of EM[22, 23]. Regarding postural drainage, it has been reported that the sitting or supine positions during ventilator management are effective in preventing respiratory complications[24]. In addition, a retrospective Italian multicenter study reported that supine therapy in ARDS patients secondary to COVID-19 contributed to improved lung compliance, oxygenation, and in-hospital mortality[25]. On the other hand, there is no sufficient evidence that manual coughing techniques, such as bag-valve-mask ventilation or manual lung hyperinflation[26], prevent respiratory complications.

There are reports showing that these techniques conferred short-term improvement in oxygenation and pulmonary compliance[27], and pulmonary rehabilitation was effective in patients whose cause of decreased oxygenation is sputum plugging[28]. However, it is difficult to perform manual coughing techniques such as hyperinflation in COVID-19 patients due to the risk of aerosol exposure from coughing. In the present study, the average ventilation period was about six days in the independent group and about 16 days in the non-independent group; a difference of about 10 days. Since there was no difference in ventilator settings between the two groups, it is unlikely that respiratory dysfunction due to COVID-19 affected ambulation. Therefore, the results of the current study suggest that the ability of patients with severe COVID-19 pneumonia to walk independently at the time of discharge was likely largely related to their general condition and the presence or absence of complications, rather than their respiratory function.

The limitations of the present study are three-fold. The first is the existence of cases for which the duration of physical therapy was extremely short due to the COVID-19 pandemic, during which we had to transfer patients back to their local hospitals. Second, there were cases in which it was difficult to estimate the date of onset, and the overall course of the disease was unclear. COVID-19 is known to take around 7 to 10 days from onset to exacerbation to severe disease; Gattinoni et al. proposed that ARDS secondary to COVID-19 is characterized by increased vascular permeability with increased minute volume as a mechanism of severity[29]. Because of this mechanism, physical therapy immediately after infection may actually worsen the patient's condition. Third, the present study only focused on COVID-19, and did not perform any comparisons with other syndromes; therefore, we believe it is necessary for future studies to investigate background factors of impaired ambulation (physical mobility, physical function, etc.) in more detail.

In conclusion, in the present study, age and duration of mechanical ventilation were extracted as independent factors to predict independent walking ability at discharge in patients with severe COVID-19 pneumonia. An age of 56 years and a ventilation duration of 7.5 days were the cutoffs for independent ambulation at discharge. The accuracy rate of 78% is promising, but caution is needed when examining other factors and their validity.

The results of the present study indicate the importance for physical therapists to shorten the ventilation period by providing respiratory physiotherapy, such as therapy for expectoration, positioning, and weaning.

Funding and Conflicts of interest

None.

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