doi: 10.2490/prm.20230020 Progress in Rehabilitation Medicine 2023; Vol. 8, 20230020

CASE REPORT

Functional Recovery and Nutrition Management among Severe COVID-19 Cases during Post-extubation Hospitalization: A Case Series

Akiyoshi Nagatomi, MD [a] Haruaki Wakatake, MD, PhD [a] Yoshihiro Masui, MD, PhD [a]
Koichi Hayashi, MD, PhD [a] and Shigeki Fujitani, MD, PhD [b]

Background: Many patients with coronavirus disease 2019 (COVID-19) develop malnutrition after a prolonged stay in the intensive care unit (ICU) with mechanical ventilation. Early enteral nutrition is recommended, but optimal nutrition management during post-extubation recovery remains challenging. **Cases:** The subjects were 12 acute respiratory distress syndrome patients with COVID-19 (9 men, 3 women; median age, 55.6 years). We reviewed patient characteristics, physical function, and nutrient intake during hospitalization from just after extubation to discharge. During this period, the median Functional Oral Intake Scale score improved from 4.5 (interquartile range [IQR] 3.3–5.3) to 7.0 (IQR 5.8–7.0), the median Medical Research Council (MRC) scale score improved from 45.0 (IQR 39.3–48.5) to 53.5 (IQR 47.5–59.3), and the median Barthel index improved from 7.5 (IQR 0–16.3) to 72.5 (IQR 42.5–95.0). In 3 patients, the MRC scale score remained below 48 before discharge, indicating that ICU-acquired weakness had been prolonged. The median daily caloric intake during this phase increased from 6.9 kcal/kg per day (3.5–10.2 kcal/kg per day) to 24.8 kcal/kg per day (21.0–27.9 kcal/kg per day). About half of these patients showed caloric intake below 25 kcal/kg per day before discharge. Based on the Global Leadership Initiative on Malnutrition (GLIM) diagnostic scheme, 10 patients were diagnosed with malnutrition during hospitalization. **Discussion:** Physical function improved in more than half of the patients, but nutritional status was not recovered. More studies for nutritional management are required to prevent malnutrition and to enhance functional recovery during the post-extubation rehabilitation phase.

Key Words: COVID-19; dysphagia; nutrition; post-extubation

INTRODUCTION

Coronavirus disease 2019 (COVID-19) has affected tens of millions of people in Japan.[1)] This virus can cause multi-organ dysfunction resulting in significant morbidity and mortality.[2)] Because of the nature of the respiratory infection, patients with COVID-19 may experience pulmonary compromise, resulting in hypoxic respiratory failure or acute respiratory distress syndrome (ARDS). Ultimately, patients may require respiratory management, including intubated mechanical ventilation, proning, neuromuscular blockade and sedation, antiviral and anti-inflammatory drugs, strategic nutrition support, and extracorporeal membrane oxygenation (ECMO).[3)]

Post-extubation dysphagia (PED) caused by prolonged intubated mechanical ventilation has been considered an important sequela among patients with severe COVID-19.[4–7)] To minimize the potential clinical complications of PED, such as aspiration pneumonia and malnutrition, functional recovery from this swallowing disorder requires prompt

Received: March 15, 2023, Accepted: June 6, 2023, Published online: July 12, 2023
[a] Department of Emergency and Critical Care Medicine, St. Marianna University Yokohama City Seibu Hospital, Yokohama, Japan
[b] Department of Emergency and Critical Care Medicine, St. Marianna University, School of Medicine, Yokohama, Japan
Correspondence: Akiyoshi Nagatomi, MD, 1197-1 Yasashi-cho, Asahi-ku, Yokohama, Kanagawa 241-0811, Japan, E-mail: akiyoshi.nagatomi@marianna-u.ac.jp

evaluation and management of dysphagia by an interdisciplinary team, including a speech and language pathologist (SLP), a dietitian, and other medical staff. Optimal caloric and protein intakes are also necessary to enhance recovery of functional muscle mass and to prevent further loss, but patients are at risk of reductions in caloric and protein intakes after cessation of enteral nutrition and removal of the feeding tube.[8–10]

Recent recommendations regarding nutrition management in patients with COVID-19 have been issued by the European Society on Enteral and Parenteral Nutrition and the American Society for Parenteral and Enteral Nutrition.[11,12] Early enteral nutrition is recommended during invasive mechanical ventilation, but optimal management during the early recovery phase following discharge from the intensive care unit (ICU), representing the rehabilitation period, is challenging.[13,14]

Few reports have described the physical function and conditions of actual nutrition delivery among COVID-19 patients with PED during the post-extubation hospitalization.[15] We report herein on the recovery of physical function and nutrition management among 12 COVID-19 cases during early post-extubation hospitalization.

CASES

Participants

This single-center case series included patients with COVID-19 admitted to the Critical Care Center (CCC), a combination unit in our institute consisting of an ICU and an intermediate unit, between December 2020 and September 2021. During the study period, 306 COVID-19 patients were admitted to the CCC, with intubated mechanical ventilation performed for 22 patients. Of these, 7 patients died under mechanical ventilation and 3 were transferred to other hospitals for ECMO. The remaining 12 patients (9 men, 3 women; median age, 55.6 years; interquartile range [IQR], 43.8–63.8 years) were successfully weaned from invasive mechanical ventilation. None of these 12 patients had previous dysphagia or neurological diseases. Activities of daily living (ADL) were confirmed as independent before COVID-19 infection. COVID-19 was diagnosed based on a positive polymerase chain reaction test result for severe acute respiratory syndrome coronavirus 2.

This study was approved by the Research Ethics Committee of St. Marianna University School of Medicine (approval no. 5849) in accordance with the Declaration of Helsinki. Written informed consent was obtained from all individuals included in the study.

Rehabilitation Management

During the intubation phase, particularly in the early acute phase, a prone position has been recommended for providing mechanical ventilation with administration of a muscle relaxant. In this phase, the prone position and sputum drainage were performed by a multidisciplinary team (comprising a doctor, nurse, and physical therapist). The prone position was kept to about 16 h/day and was performed for several days. After cessation of muscle relaxant administration, respiratory function was assessed daily by the physical therapist and doctors. Passive range-of-motion exercises were performed. If a patient could follow simple instructions, active range-of-motion exercises were also attempted. During the post-extubation phase, sitting and standing, muscle strength training, and respiratory exercises such as huff coughing were prescribed. If possible, walking exercises were attempted. However, daily activities were restricted to the bedside or within a hospital room because of the need to prevent nosocomial COVID-19.

To evaluate swallowing dysfunction, bedside swallowing evaluation (BSE) was performed by a SLP wearing personal protective equipment. Intake trials were performed with foods of different consistency, including thin liquid, nectar, puréed solid, and solid. All intakes were administered unless considered unsafe by the treating SLP. This safety determination was left to the discretion of the SLP. Fiberoptic endoscopic evaluation of swallowing (FEES) was performed by an otolaryngologist if needed after the cessation of infectious risk. Occupational therapy was not prescribed because of COVID-19 infection control measures.

Nutrition Management

During the intubation phase, all patients were given a feeding tube for enteral nutrition (EN), which was started within 48 h, unless restrictions were in place to delay EN. Parenteral nutrition was considered only when caloric intake had been insufficient by EN alone for several days. Calories and proteins were prescribed based on the actual body weight of each patient and gradually progressed to a target for about 3–4 days after starting EN. The prescribed target was 1.3 g/kg per day for proteins and 70% of calculated resting energy expenditure (REE) for calories. These targets for daily caloric and protein intakes were maintained until extubation.[16]

During the post-extubation phase, the type of nutrition support (EN, oral intake, or both) and food consistencies were determined based on the BSE by a SLP. Furthermore, targeted daily caloric and protein intakes were increased to 125% of predictive equations and 1.5–2.0 g/kg per day, respectively, based on the literature.[16)]

Data Collection: Demographics and Clinical Characteristics

We reviewed the following data as patient characteristics on admission: height and weight; and preexisting comorbidities. ICU severity was evaluated based on scores for the Acute Physiology and Chronic Health Evaluation (APACHE)-II and Sequential Organ Failure Assessment (SOFA).

We also collected additional recorded parameters such as the duration of invasive mechanical ventilation and post-extubation, the use of muscle relaxant, the presence of reintubation and tracheostomy, length of stay (LOS) in the CCC, LOS in hospital, and discharge disposition (discharge to home or another institution). We also reviewed whether patients were positioned prone ("proning") during intubation. The P/F ratio [partial pressure of oxygen (PaO_2)/fraction of inspired oxygen (FiO_2)] was calculated for each patient prior to intubation.

Data Collection: Physical Function and ADL

As soon as possible after extubation, each patient was assessed according to the Medical Research Council (MRC) scale for total muscle strength, the Functional Oral Intake Scale (FOIS) for swallowing function, and Barthel index for measuring ADL. These assessments were also conducted for each patient just before discharge. The MRC scale was evaluated by physical therapists, and the FOIS was evaluated by SLPs. The MRC scale score is used for manual muscle testing to assess the strength of the muscle groups of the upper and lower limbs. The total score ranges from 0 (complete tetraplegia) to 60 (normal muscle strength). The FOIS score is evaluated on the following 7-point ordinal scale: 1=nil by mouth; 2=tube dependent with minimal attempts of food and fluid; 3=tube dependent with consistent intake of food and fluid; 4=total oral intake of a single consistency; 5=total oral intake of multiple consistencies requiring special preparations; 6=total oral intake with multiple consistencies without special preparations, but minimal restrictions; and 7=total oral diet with no restrictions. FOIS levels 1–5 are considered as indicative of dysphagia, whereas levels 6 and 7 indicate functional swallowing.

Data Collection: Assessment of Malnutrition and Nutrition Quantification of Daily Calorie and Protein Intakes

We reviewed each patient's malnutrition status based on the Global Leadership Initiative on Malnutrition (GLIM) diagnostic scheme, which includes screening, assessment, diagnosis, and grading of malnutrition.[17)] To assess nutritional risk, we used the Nutritional Risk Screening-2002 (NRS-2002) on admission.[18)] Body weight was measured at three time points: on admission, the day after extubation (post-extubation), and before discharge. Weight loss and body mass index (BMI) were calculated. We assessed phenotypic criteria for grading diagnosis and severity of malnutrition during hospitalization.

The total amount of daily EN during intubation was reviewed to calculate mean daily caloric and protein intakes. During the post-extubation phase, the total amount of nutrition administered daily was quantified and causes of cessation or reduction of food intake were extracted from the nursing chart review. In this report, indirect calorimetry was not used to measure the caloric intake because of the need to avoid infectious risk.

Statistical Analysis

Descriptive statistics are reported as median and IQR for continuous data. Categorical variables are presented as frequency and percentage or number. Some data were compared using a two-tailed Wilcoxon signed rank test. A two-sided alpha of less than 0.05 was considered statistically significant. Statistical analyses were completed using R statistical software, ver. 4.0.1 (R Foundation for Statistical Computing, Vienna, Austria).

Findings

Patient characteristics on admission and during the invasive mechanical ventilation phase are shown in **Table 1**. The median P/F ratio before intubation was 118.9 (IQR, 82.9–124.4). The NRS score (screening test) of each patient was 3 or 4, which indicated a risk of malnutrition; however, the median BMI was 25.3 kg/m^2(IQR, 24.5–25.8 kg/m^2) on admission. Weight loss and reduced muscle mass had not been observed in all patients until admission. Based on the GLIM diagnostic scheme, no patients were diagnosed with malnutrition on admission. All patients were treated with Remdesivir antiviral therapy, dexamethasone, and anticoagulant therapy. Muscle relaxant was used in 9 patients, with a median duration of continuous venous muscle relaxant injection of 49.4 h (IQR, 24.5–53.8 h). Proning was used in

Table 1. Patient characteristics

Case	Age (years)	Sex (male/female)	SOFA score	APACHE II score	NRS 2002	P/F ratio before intubation	Muscle relaxant use (h)	Proning (yes/no)	Admission to intubation (days)	Intubation duration (days)	Post-extubation duration (days)	LOS in CCC (days)	Hospital LOS (days)	Discharge disposition (home/other institution)
1	73	F	8	9	4	69.8	24	No	1	16[a]	23	40	40	Other institution
2	58	M	11	18	3	117.7	49	Yes	2	8	11	21	21	Other institution
3	42	M	3	2	3	121.5	8	Yes	3	10	6	19	19	Other institution
4	73	M	4	12	4	133	Not used	Yes	2	18	22	42	42	Other institution
5	56	M	8	7	3	83	18	Yes	5	11	13	29	29	Other institution
6	66	F	3	14	3	209	47	Yes	0	11	9	20	20	Other institution
7	54	M	7	15	3	331	Not used	Yes	0	13	17	30	56	Home
8	44	M	4	8	3	82.6	58	Yes	0	10	10	15	20	Other institution
9	40	M	4	5	3	80.7	Not used	Yes	1	19	12	26	32	Home
10	63	M	3	5	3	120.1	53	Yes	1	15	5	21	21	Other institution
11	55	F	4	9	3	90.6	50	Yes	0	11	4	15	15	Other institution
12	43	M	4	3	3	121.1	62	Yes	0	14	3	17	17	Home
Summary	55.6 (43.8–63.8)	9/3	4.0 (3.2–7.2)	8.5 (5.0–13.5)	3 (3–3)	118.9 (82.9–124.4)	49.4 (24.5–53.8)	11/1	1 (0–2)	12.0 (10.8–15.3)	10.5 (5.8–14.0)	21.0 (18.5–29.3)	21.0 (19.8–34.0)	3/9

Data are summarized and displayed as median (IQR) or number.
[a] Duration from intubation to tracheostomy.

Table 2. Functional recovery and ADL changes

Case	FOIS score		MRC scale score		Barthel index	
	Post-extubation	Before discharge	Post-extubation	Before discharge	Post-extubation	Before discharge
1	1	4	41	42	0	5
2	1	7	48	54	0	75
3	5	7	46	60	0	95
4	1	5	34	46	0	35
5	6	7	50	58	5	95
6	6	7	44	48	15	80
7	6	6	43	53	5	50
8	4	7	52	60	15	70
9	5	7	52	60	25	100
10	5	7	46	48	10	45
11	4	5	34	34	20	20
12	4	6	32	59	20	95
Summary	4.5 (3.3–5.3)	7.0 (5.8–7.0)	45.0 (39.3–48.5)	53.5 (47.5–59.3)	7.5 (0–16.3)	72.5 (42.5–95.0)

Data are summarized and displayed as median (IQR) or number.

11 of the 12 patients (91.6%), with a median duration of 4 days (IQR, 2.5–5.0 days). Eleven of the 12 cases experienced ventilation-associated pneumonia under mechanical ventilation. Tracheostomy was performed in 1 patient (Case 1). Comorbidities included diabetes mellitus in 2 patients (Cases 2 and 4), chronic obstructive pulmonary disease in 1 patient (Case 1), chronic renal failure (CRF) with hemodialysis in 1 patient (Case 2), and old myocardial infarction in 1 patient (Case 7).

The median duration of the post-extubation phase was 10.5 days (IQR, 5.8–14.0 days). The median LOS in the CCC was 21.0 days (IQR, 18.5–29.3 days) and the median LOS in hospital was 21.0 days (IQR, 19.8–34.0 days). Upon discharge, 3 patients were discharged to home and 9 patients were discharged to other institutions.

The median duration between extubation and the first PED assessment by a SLP was 1.5 days (IQR, 0.8–3.0 days). The FOIS scores in 9 patients were in the range of 1–5 (indicative of dysphagia); the remaining 3 patients each had a FOIS score of 6 (**Table 2**). After evaluation by a SLP, 1 patient experienced persistent PED and feeding tube nutrition was combined with oral intake until discharge (Case 4). Two patients showed transient PED with EN administered by feeding tube for several days (Cases 2 and 6). The patient who underwent tracheostomy (Case 1) was restricted to thick liquid and so took a single consistency orally combined with feeding tube nutrition until discharge. FEES was performed in only 1 case (Case 7) for vocal discomfort during the post-extubation phase. Although vocal cord dysfunction was suspected, the patient reported no concerns with dysphagia, so oral intake was not suspended before discharge. Among all patients, the median FOIS score improved significantly from 4.5 (IQR, 3.3–5.3) at first BSE to 7.0 (IQR, 5.8–7.0; P=0.004) just before discharge.

The median MRC scale score on the day after extubation was 45.0 (IQR, 39.3–48.5) (**Table 2**). Eight patients were suspected of having ICU-acquired weakness (ICU-AW) because their MRC scores were less than 48. Six of those eight patients also showed affected swallowing function (Cases 1, 3, 4, 10, 11, and 12). The median MRC scale score just before discharge was increased to 53.5 (IQR, 47.5–59.3). In three patients (Cases 1, 4, and 11), the MRC scale score was still less than 48 before discharge, indicating that ICU-AW had been prolonged. Dominant-hand grip strength was measured in seven patients before discharge (Cases 2, 3, 4, 5, 7, 8, and 10). The median dominant-hand grip strength was 26.0 kg (IQR, 18.0–34.0 kg). The median Barthel index was 7.5 (IQR, 0–16.3) post-extubation and increased to 72.5 (IQR,

Table 3. Daily intake of calories and protein at first time post-extubation and before discharge

Case	Daily caloric intake (kcal/day)		Daily caloric intake per BW (kcal/kg per day)		Daily protein intake (g/day)		Daily protein intake per BW (g/kg per day)	
	Post-extubation	Before discharge	Post-extubation	Before discharge	Post-extubation	Before discharge	Post-extubation	Before discharge
1	500	1485	9.3	27.7	19	56	0.4	1.1
2	900	1500	12.9	21.5	57	65	0.8	1.6
3	1000	1800	15.9	28.6	63	113	1.0	1.8
4	130	1995	1.8	27.8	8	81	0.1	1.1
5	600	1800	8.8	26.4	25	75	0.4	1.1
6	1050	1800	20.3	34.7	66	70	1.3	1.4
7	180	1767	2.4	23.2	8	70	0.1	0.9
8	300	1500	3.4	17.2	0	75	0.0	0.9
9	495	2000	7.0	28.3	18	75	0.3	1.1
10	467	1353	6.8	19.6	18	53	0.3	0.8
11	300	990	4.6	15.2	0	36	0.0	0.6
12	248	1513	3.5	21.7	9	55	0.1	0.8
Summary	481 (287–675)	1640 (1489–1800)	6.9 (3.5–10.2)	24.8 (21.0–27.9)	18.0 (8.0–33.0)	70.0 (55.8–75.0)	0.3 (0.1–0.5)	1.1 (0.9–1.2)

Data are summarized and displayed as median (IQR) or number.
BW, body weight.

42.5–95.0) just before discharge (P=0.003).

The median daily caloric intake during the intubation phase was 1042 kcal/day (IQR, 887–1204 kcal/day), representing 63.4% (IQR, 49.8–72.2%) of the calculated REE. The median daily protein intake during the intubation phase was 55.5 g/day (IQR, 44.2–65.3 g/day), which was equivalent to 0.8 g/kg per day (IQR, 0.5–1.0 g/kg per day). EN was temporarily suspended in six patients because of several complications. Parenteral nutrition was administered in addition to EN in Case 12 in an attempt to provide sufficient nutrients.

Daily caloric and protein intakes during post-extubation hospitalization are shown in **Table 3**. From the first BSE by a SLP, the median daily caloric intake was calculated as 481 kcal/day (IQR, 287–675 kcal/day), which was equivalent to 6.9 kcal/kg per day (IQR, 3.8–10.2 kcal/kg per day). Just before discharge, the median daily caloric intake was evaluated as 1640 kcal/day (IQR, 1496–1800 kcal/day), which was equivalent to 24.8 kcal/kg per day (IQR, 21.0–27.9 kcal/kg per day). At first BSE, the median daily protein intake was 18.0 g/day (IQR, 8.0–33.0 g/day), which was equivalent to 0.3 g/kg per day (IQR, 0.1–0.5 g/kg per day). Just before discharge, the median daily protein intake was 70.0 g/day (IQR, 55.8–75.0 g/day), which was equivalent to 1.1 g/kg per day (IQR, 0.9–1.2 g/kg per day). Each patient was assessed for appetite and level of satiety. For Case 7, the dietitian proposed milk and supplement jelly in addition to the ordinary diet to increase caloric and protein intakes. Food intake during the post-extubation phase was halted or reduced because of the following reasons: Case 1, tracheostomy and sustained dysphagia; Case 2, gastrointestinal bleeding; Cases 4 and 11, sustained PED; Case 5, abdominal pain caused by rectus sheath hematoma; Cases 5 and 10, use of non-invasive ventilation (NIV); Case 6, patient's fear of aspiration; Cases 8 and 12, loss of appetite or early satiety; Case 7, abdominal pain caused by subcutaneous hematoma in the left abdominal wall and unsuitable food consistency.

Two patients with dysphagia and ICU-AW before discharge (Cases 1 and 4) could not improve ADL, although adequate energy intake (>25 kcal/kg per day) was administered by enteral nutrition during the post-extubation phase. One patient (Case 11) with suspected ICU-AW and dysphagia had inadequate energy intake before discharge. Among patients without ICU-AW before discharge, those with inadequate energy intake (<25 kcal/kg per day; Cases 2, 7, 8, 10, 11, and 12) tended to show lower Barthel indices than patients with adequate energy intake (Cases 3, 5, 6, and 9).

During hospitalization, weight loss was observed in 11 patients, and the median percentage of weight loss was −8.1% (IQR, −9.8 to −7.0). The median low BMI was 23.0 kg/m^2(IQR, 22.4–23.6 kg/m^2) (**Table 4**). Based on the GLIM diagnostic scheme, 10 patients were diagnosed with malnutrition during hospitalization. Seven of these 10 patients (Cases

Table 4. Body weight change, weight loss, and low BMI during hospitalization

Case	Height (cm)	Weight (kg)			Maximum weight loss (kg)	Weight loss (%)	Low BMI (kg/m^2)
		On admission	Post-extubation	Before discharge			
1	148	56.0	53.6	50.8	−5.2	−9.3	23.2
2	172	66.0	69.8	67.4	+3.8	+5.8	22.3
3	168	68.6	62.9	63.4	−5.7	−8.3	22.3
4	172	72.8	71.9	67.0	−5.8	−8.0	22.6
5	172	73.2	68.1	68.1	−5.1	−7.0	23.0
6	160	58.4	51.8	51.6	−6.8	−11.6	20.2
7	180	81.9	76.3	73.7	−8.2	−10.0	22.7
8	177	90.8	87.2	87.4	−3.6	−4.0	27.8
9	172	75.7	70.6	70.3	−5.5	−7.2	23.7
10	173	75.5	69.0	68.7	−6.8	−9.0	23.0
11	159	70.0	65.1	65.1	−4.9	−7.0	25.8
12	173	78.4	69.8	69.4	−9.0	−11.5	23.2
Summary	172 (162–173)	73.0 (66.7–77.7)	69.4 (63.5–71.5)	67.8 (63.8–70.0)	−5.6 (−6.8 to −5.0)	−8.1 (−9.8 to −7.0)	23.0 (22.4–23.6)

Data are summarized and displayed as median (IQR) or as number.

1, 3, 4, 5, 9, 10, and 11) were classified as having moderate malnutrition, and 3 patients (Cases 6, 7, and 12) were classified as having severe malnutrition during hospitalization. Although 2 patients were not diagnosed with malnutrition, 1 case (Case 8) had 4% weight loss and the other patient (Case 2) had continuous renal replacement therapy to control his volume status during intubation and post-extubation phases.

DISCUSSION

The present case series retrospectively summarized the functional recovery and nutrition management among 12 patients with critical COVID-19 during post-extubation hospitalization. Soon after extubation, more than half of the patients had a MRC scale score that was below 48, and 3 patients remained in a state of muscle weakness before discharge, diagnosed as ICU-AW. ICU-AW results from significant muscle wastage, decreased muscle contractile strength, and neuropathies. The prevalence of ICU-AW in patients with COVID-19 has been reported as 70%–100%,[19,20] which is higher than the rates reported for patients receiving mechanical ventilation for conditions other than COVID-19.[21,22] ICU-AW is also associated with a reduced ability of or complete loss of volitional feeding, often resulting in reduced dietary intake. Inability to feed oneself independently persists well into the recovery phase of illness. In terms of dysphagia, 9 of the 12 patients (75%) were diagnosed with dysphagia based on the FOIS score at first BSE and dysphagia was sustained in 3 patients (25%). The prevalence of PED among patients with COVID-19 is similar to that stated in previous reports (22.4%–100%).[4–7,23–25]

Our results demonstrated that during the post-extubation period, daily median caloric and protein intakes increased from 6.9 kcal/kg per day (IQR, 3.5–10.2 kcal/kg per day) and 0.3 g/kg per day (IQR, 0.1–0.5 g/kg per day) at first BSE to 24.8 kcal/kg per day (IQR, 20.1–27.9 kcal/kg per day) and 1.1 g/kg per day (IQR, 0.9–1.2 g/kg per day), respectively, just before discharge. However, six patients showed caloric intakes that were less than 25 kcal/kg per day just before discharge. These cases received oral intake alone. Previous studies have shown that patients relying on oral diet alone during the early phases of ward-based recovery consume 55%–75% of prescribed calories and 27%–74% of prescribed protein, further contributing to the caloric and protein deficiencies commonly associated with patients in the ICU.[26] In contrast, patients who continue to receive enteral nutrition, with or without oral diet, fare considerably better.[8–10] These data suggest that prolonged tube feeding until sufficient oral nutrition intake is achieved should be considered as an alternative to usual care.[16,26] In this study, two patients (Cases 1 and 4) had both EN and oral intake. Although provision of nutrients was temporarily suspended during the post-extubation phase, both patients achieved the target caloric intake (>25 kcal/kg per day) before discharge.

Placement of a feeding tube in the pharynx may be useful for patients with sustained PED, but the feeding tube may cause delirium[27] and eventually may cause restriction of early mobilization and prolonged ICU-AW. To prevent these symptoms, both ordinary oral intake and oral nutritional supplementation should be considered to maintain caloric and protein intakes and to avoid prolonged tube feeding. In one case (Case 7), oral intake supplements were prescribed to increase caloric intake.

Gastrointestinal bleeding and abdominal pain caused by abdominal wall hematoma have been reported as complications and barriers to oral intake. Venous thrombosis is one of the major complications in COVID-19.[28] Anticoagulation therapy using unfractionated heparin is recommended for the prevention of thromboembolism, but bleeding in organs or other tissues occurs in 2.3%–3.8% of cases.[29] In our cases, this therapy was stopped soon after the detection of bleeding and low-dose molecular heparin was adopted instead. Oral intake was suspended until there was no sign of extravasation bleeding. Abdominal pain resulted in appetite loss and nausea, which led to reduced oral intake.

NIV was another barrier to oral intake during the early post-extubation phase. NIV was prescribed for post-extubation patients with sustained respiratory dysfunction because these patients were at high risk of PED and aspiration pneumonia. Furthermore, the recommendation to start enteral feeding can be obstructed by the fact that placement of a nasogastric tube for nutrition may result in air leakage that may compromise the effectiveness of NIV. In addition, stomach dilatation from feeding may affect both diaphragmatic function and NIV effectiveness.[30] In this case series, two patients were administered NIV for several days. After cessation of NIV, oral intake was resumed, and daily caloric intake was increased.

To restore lost muscle mass, enhance the recovery of functional muscle mass, and improve quality of life during the post-extubation phase, the optimal caloric intake is considered to be 2000–4000 kcal/day or 1.7-fold above the REE.[31,32] Nevertheless, no formal recommendations or guidelines on energy and protein intake have yet been developed for this phase. At present, the daily caloric intake is suggested to be up to 125% of targets identified by predictive equations or indirect calorimetry or doses of 30 kcal/kg per day and daily protein intake of 1.5–2.0 g/kg per day should be considered.[16] Based on this suggestion, we administered the optimal oral intake for post-extubation COVID-19 patients. However, adequate nutrition intake was still not obtained for several of the aforementioned reasons. In this case series, most patients were diagnosed with malnutrition during hospitalization based on the GLIM diagnostic scheme. More studies are required to determine the adequate caloric intake for severe ARDS patients with COVID-19 and to develop an effective method that ensures adequate caloric and protein intakes.

CONCLUSION

The present case series study monitored the nutrition management and function recovery from swallowing disorder among 12 ARDS patients with COVID-19 during post-extubation hospitalization. Although physical function improved in more than half of these patients during the post-extubation phase, malnutrition was also diagnosed in almost all patients during this period. More studies of nutritional management are required to prevent malnutrition and to enhance physical function during the post-extubation phase.

ACKNOWLEDGMENTS

We thank all participants across clinical settings for agreeing to contribute data to this study. We also acknowledge the assistance provided by rehabilitation staff, particularly the SLPs, and nutrition support team members in our facility.

CONFLICTS OF INTEREST

The authors have no conflict of interest to declare.

REFERENCES

1. Ministry of Health Labor and Welfare of Japan: Visualizing the data: information on COVID19 infection. Ministry of Health Labor and Welfare of Japan. 2023. https://covid19.mhlw.go.jp/. Accessed 14 February 2023.
2. Mokhtari T, Hassani F, Ghaffari N, Ebrahimi B, Yarahmadi A, Hassanzadeh G: COVID-19 and multiorgan failure: a narrative review on potential mechanisms. J Mol Histol 2020;51:613–628. https://doi.org/10.1007/s10735-020-09915-3, PMID:33011887
3. Ministry of Health Labor and Welfare of Japan: Clinical guideline for management COVID19 infection version 8.1. Ministry of Health Labor and Welfare of Japan. 2022. https://www.mhlw.go.jp/content/000997789.pdf. Accessed 14 February 2023.

4. Sassi FC, Ritto AP, de Lima MS, Valente Junior CN, Cardoso PF, Zilberstein B, Saldiva PH, de Andrade CR: Characteristics of postintubation dysphagia in ICU patients in the context of the COVID-19 outbreak: a report of 920 cases from a Brazilian reference center. PLoS One 2022;17:e0270107. https://doi.org/10.1371/journal.pone.0270107, PMID:35709233
5. Dawson C, Capewell R, Ellis S, Matthews S, Adamson S, Wood M, Fitch L, Reid K, Shaw M, Wheeler J, Pracy P, Nankivell P, Sharma N: Dysphagia presentation and management following COVID-19: an acute care tertiary centre experience. J Laryngol Otol 2020;134:1–6. https://doi.org/10.1017/S0022215120002443, PMID:33168109
6. Nasa P, Azoulay E, Chakrabarti A, Divatia JV, Jain R, Rodrigues C, Rosenthal VD, Alhazzani W, Arabi YM, Bakker J, Bassetti M, De Waele J, Dimopoulos G, Du B, Einav S, Evans L, Finfer S, Guérin C, Hammond NE, Jaber S, Kleinpell RM, Koh Y, Kollef M, Levy MM, Machado FR, Mancebo J, Martin-Loeches I, Mer M, Niederman MS, Pelosi P, Perner A, Peter JV, Phua J, Piquilloud L, Pletz MW, Rhodes A, Schultz MJ, Singer M, Timsit JF, Venkatesh B, Vincent JL, Welte T, Myatra SN: Infection control in the intensive care unit: expert consensus statements for SARS-CoV-2 using a Delphi method. Lancet Infect Dis 2022;22:e74–e87. https://doi.org/10.1016/S1473-3099(21)00626-5, PMID:34774188
7. Frajkova Z, Tedla M, Tedlova E, Suchankova M, Geneid A: Postintubation dysphagia during COVID-19 outbreak—contemporary review. Dysphagia 2020;35:549–557. https://doi.org/10.1007/s00455-020-10139-6 , PMID:32468193
8. Chapple LS, Deane AM, Heyland DK, Lange K, Kranz AJ, Williams LT, Chapman MJ: Energy and protein deficits throughout hospitalization in patients admitted with a traumatic brain injury. Clin Nutr 2016;35:1315–1322. https://doi.org/10.1016/j.clnu.2016.02.009, PMID:26949198
9. Ridley EJ, Parke RL, Davies AR, Bailey M, Hodgson C, Deane AM, McGuinness S, Cooper DJ: What Happens to nutrition intake in the post-intensive care unit hospitalization period? An observational cohort study in critically ill adults. JPEN J Parenter Enteral Nutr 2019;43:88–95. https://doi.org/10.1002/jpen.1196, PMID:29924393
10. Moisey LL, Pikul J, Keller H, Yeung CY, Rahman A, Heyland DK, Mourtzakis M: Adequacy of protein and energy intake in critically ill adults following liberation from mechanical ventilation is dependent on route of nutrition delivery. Nutr Clin Pract 2021;36:201–212. https://doi.org/10.1002/ncp.10558, PMID:32717141
11. Martindale R, Patel JJ, Taylor B, Arabi YM, Warren M, McClave SA: Nutrition therapy in critically ill patients with coronavirus disease 2019. JPEN J Parenter Enteral Nutr 2020;44:1174–1184. https://doi.org/10.1002/jpen.1930, PMID:32462719
12. Barazzoni R, Bischoff SC, Breda J, Wickramasinghe K, Krznaric Z, Nitzan D, Pirlich M, Singer P, endorsed by the ESPEN Council: ESPEN expert statements and practical guidance for nutritional management of individuals with SARS-CoV-2 infection. Clin Nutr 2020;39:1631–1638. https://doi.org/10.1016/j.clnu.2020.03.022, PMID:32305181
13. Zuercher P, Moret CS, Dziewas R, Schefold JC: Dysphagia in the intensive care unit: epidemiology, mechanisms, and clinical management. Crit Care 2019;23:103. https://doi.org/10.1186/s13054-019-2400-2, PMID:30922363
14. Peterson SJ, Tsai AA, Scala CM, Sowa DC, Sheean PM, Braunschweig CL: Adequacy of oral intake in critically ill patients 1 week after extubation. J Am Diet Assoc 2010;110:427–433. https://doi.org/10.1016/j.jada.2009.11.020, PMID:20184993
15. Hoyois A, Ballarin A, Thomas J, Lheureux O, Preiser JC, Coppens E, Perez-Bogerd S, Taton O, Farine S, Van Ouytsel P, Arvanitakis M: Nutrition evaluation and management of critically ill patients with COVID-19 during post-intensive care rehabilitation. JPEN J Parenter Enteral Nutr 2021;45:1153–1163. https://doi.org/10.1002/jpen.2101, PMID:33666263
16. van Zanten AR, De Waele E, Wischmeyer PE: Nutrition therapy and critical illness: practical guidance for the ICU, post-ICU, and long-term convalescence phases. Crit Care 2019;23:368. https://doi.org/10.1186/s13054-019-2657-5, PMID:31752979

17. Cederholm T, Jensen GL, Correia MI, Gonzalez MC, Fukushima R, Higashiguchi T, Baptista G, Barazzoni R, Blaauw R, Coats A, Crivelli A, Evans DC, Gramlich L, Fuchs-Tarlovsky V, Keller H, Llido L, Malone A, Mogensen KM, Morley JE, Muscaritoli M, Nyulasi I, Pirlich M, Pisprasert V, de van der Schueren MA, Siltharm S, Singer P, Tappenden K, Velasco N, Waitzberg D, Yamwong P, Yu J, Van Gossum A, Compher C, Charlene C, GLIM Core Leadership Committee, GLIM Working Group: GLIM criteria for the diagnosis of malnutrition—a consensus report from the global clinical nutrition community. Clin Nutr 2019;38:1–9. https://doi.org/10.1016/j.clnu.2018.08.002, PMID:30181091
18. Kondrup J, Allison SP, Elia M, Vellas B, Plauth M, Educational and Clinical Practice Committee, European Society of Parenteral and Enteral Nutrition (ESPEN): ESPEN guidelines for nutrition screening 2002. Clin Nutr 2003;22:415–421. https://doi.org/10.1016/S0261-5614(03)00098-0, PMID:12880610
19. McWilliams D, Weblin J, Hodson J, Veenith T, Whitehouse T, Snelson C: Rehabilitation levels in patients with COVID-19 admitted to intensive care requiring invasive ventilation. An observational study. Ann Am Thorac Soc 2021;18:122–129. https://doi.org/10.1513/AnnalsATS.202005-560OC, PMID:32915072
20. Van Aerde N, Van den Berghe G, Wilmer A, Gosselink R, Hermans G, Meersseman P, Gunst J, Aerts V, Balthazar T, Barbé A, Böhrer A, Caluwé K, Casaer MP, Coosemans I, Coppens S, Dauwe D, Debaveye Y, De Coster J, De Munter P, Demuynck L, De Sloovere V, Desmet L, De Troy E, De Vlieger G, Frickx B, Haghedooren E, Haghedooren R, Henckaerts L, Heyns A, Hornikx M, Ingels C, Jacobs B, Janssen K, Meersseman W, Meyfroidt G, Muller J, Neyrinck A, Peetermans M, Rex S, Schrijvers A, Vanbrabant P, Vandenbriele C, Van den Eynde R, van den Hauwe M, Van de Velde M, Van Hollebeke M, Van Wijngaerden E, Verelst S, Vlasselaers D, Volker C, Vrijsen B, Wauters J, Wouters PJ, COVID-19 Consortium: Intensive care unit acquired muscle weakness in COVID-19 patients. Intensive Care Med 2020;46:2083–2085. https://doi.org/10.1007/s00134-020-06244-7, PMID:32986233
21. Schweickert WD, Pohlman MC, Pohlman AS, Nigos C, Pawlik AJ, Esbrook CL, Spears L, Miller M, Franczyk M, Deprizio D, Schmidt GA, Bowman A, Barr R, McCallister KE, Hall JB, Kress JP: Early physical and occupational therapy in mechanically ventilated, critically ill patients: a randomised controlled trial. Lancet 2009;373:1874–1882. https://doi.org/10.1016/S0140-6736(09)60658-9, PMID:19446324
22. Appleton RT, Kinsella J, Quasim T: The incidence of intensive care unit-acquired weakness syndromes: a systematic review. J Intensive Care Soc 2015;16:126–136. https://doi.org/10.1177/1751143714563016, PMID:28979394
23. Bordejé Laguna L, Marcos-Neira P, de Lagrán Zurbano IM, Marco EM, Guisasola CP, Viñas Soria CD, Martí PR: Dysphagia and mechanical ventilation in SARS-COV-2 pneumonia: it's real. Clin Nutr 2022;41:2927–2933. https://doi.org/10.1016/j.clnu.2021.11.018 , PMID:34879968
24. Sandblom OH, Dotevall H, Svennerholm K, Tuomi L, Finizia C: Characterization of dysphagia and laryngeal findings in COVID-19 patients treated in the ICU—an observational clinical study. PLoS One 2021;16:e0252347. https://doi.org/10.1371/journal.pone.0252347 , PMID:34086717
25. Regan J, Walshe M, Lavan S, Horan E, Murphy PG, Healy A, Langan C, Malherbe K, Murphy BF, Cremin M, Hilton D, Cavaliere J, Whyte A: Post-extubation dysphagia and dysphonia amongst adults with COVID-19 in the Republic of Ireland: a prospective multi-site observational cohort study. Clin Otolaryngol 2021;46:1290–1299. https://doi.org/10.1111/coa.13832 , PMID:34197688
26. Moisey LL, Merriweather JL, Drover JW: The role of nutrition rehabilitation in the recovery of survivors of critical illness: underrecognized and underappreciated. Crit Care 2022;26:270. https://doi.org/10.1186/s13054-022-04143-5, PMID:36076215
27. Bellelli G, Morandi A, Di Santo SG, Mazzone A, Cherubini A, Mossello E, Bo M, Bianchetti A, Rozzini R, Zanetti E, Musicco M, Ferrari A, Ferrara N, Trabucchi M, Italian Study Group on Delirium (ISGoD): "Delirium Day": a nationwide point prevalence study of delirium in older hospitalized patients using an easy standardized diagnostic tool. BMC Med 2016;14:106. https://doi.org/10.1186/s12916-016-0649-8, PMID:27430902

28. Spyropoulos AC, Levy JH, Ageno W, Connors JM, Hunt BJ, Iba T, Levi M, Samama CM, Thachil J, Giannis D, Douketis JD, Subcommittee on Perioperative, Critical Care Thrombosis, Haemostasis of the Scientific, Standardization Committee of the International Society on Thrombosis and Haemostasis: Scientific and Standardization Committee communication: clinical guidance on the diagnosis, prevention, and treatment of venous thromboembolism in hospitalized patients with COVID-19. J Thromb Haemost 2020;18:1859–1865. https://doi.org/10.1111/jth.14929, PMID:32459046
29. Goligher EC, Bradbury CA, McVerry BJ, Lawler PR, Berger JS, Gong MN, Carrier M, Reynolds HR, Kumar A, Turgeon AF, Kornblith LZ, Kahn SR, Marshall JC, Kim KS, Houston BL, Derde LP, Cushman M, Tritschler T, Angus DC, Godoy LC, McQuilten Z, Kirwan BA, Farkouh ME, Brooks MM, Lewis RJ, Berry LR, Lorenzi E, Gordon AC, Ahuja T, Al-Beidh F, Annane D, Arabi YM, Aryal D, Baumann Kreuziger L, Beane A, Bhimani Z, Bihari S, Billett HH, Bond L, Bonten M, Brunkhorst F, Buxton M, Buzgau A, Castellucci LA, Chekuri S, Chen JT, Cheng AC, Chkhikvadze T, Coiffard B, Contreras A, Costantini TW, de Brouwer S, Detry MA, Duggal A, Džavík V, Effron MB, Eng HF, Escobedo J, Estcourt LJ, Everett BM, Fergusson DA, Fitzgerald M, Fowler RA, Froess JD, Fu Z, Galanaud JP, Galen BT, Gandotra S, Girard TD, Goodman AL, Goossens H, Green C, Greenstein YY, Gross PL, Haniffa R, Hegde SM, Hendrickson CM, Higgins AM, Hindenburg AA, Hope AA, Horowitz JM, Horvat CM, Huang DT, Hudock K, Hunt BJ, Husain M, Hyzy RC, Jacobson JR, Jayakumar D, Keller NM, Khan A, Kim Y, Kindzelski A, King AJ, Knudson MM, Kornblith AE, Kutcher ME, Laffan MA, Lamontagne F, Le Gal G, Leeper CM, Leifer ES, Lim G, Gallego Lima F, Linstrum K, Litton E, Lopez-Sendon J, Lother SA, Marten N, Saud Marinez A, Martinez M, Mateos Garcia E, Mavromichalis S, McAuley DF, McDonald EG, McGlothlin A, McGuinness SP, Middeldorp S, Montgomery SK, Mouncey PR, Murthy S, Nair GB, Nair R, Nichol AD, Nicolau JC, Nunez-Garcia B, Park JJ, Park PK, Parke RL, Parker JC, Parnia S, Paul JD, Pompilio M, Quigley JG, Rosenson RS, Rost NS, Rowan K, Santos FO, Santos M, Santos MO, Satterwhite L, Saunders CT, Schreiber J, Schutgens RE, Seymour CW, Siegal DM, Silva DG Jr, Singhal AB, Slutsky AS, Solvason D, Stanworth SJ, Turner AM, van Bentum-Puijk W, van de Veerdonk FL, van Diepen S, Vazquez-Grande G, Wahid L, Wareham V, Widmer RJ, Wilson JG, Yuriditsky E, Zhong Y, Berry SM, McArthur CJ, Neal MD, Hochman JS, Webb SA, Zarychanski R, REMAP-CAP Investigators, ACTIV-4a Investigators, ATTACC Investigators: Therapeutic anticoagulation with heparin in critically ill patients with Covid-19. N Engl J Med 2021;385:777–789. https://doi.org/10.1056/NEJMoa2103417, PMID:34351722
30. Leder SB, Siner JM, Bizzarro MJ, McGinley BM, Lefton-Greif MA: Oral alimentation in neonatal and adult populations requiring high-flow oxygen via nasal cannula. Dysphagia 2016;31:154–159. https://doi.org/10.1007/s00455-015-9669-3, PMID:26590570
31. Uehara M, Plank LD, Hill GL: Components of energy expenditure in patients with severe sepsis and major trauma: a basis for clinical care. Crit Care Med 1999;27:1295–1302. https://doi.org/10.1097/00003246-199907000-00015, PMID:10446823
32. Weijs PJ, Mogensen KM, Rawn JD, Christopher KB: Protein intake, nutritional status and outcomes in ICU survivors: a single center cohort study. J Clin Med 2019;8:43. https://doi.org/10.3390/jcm8010043, PMID:30621154