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Journal of the Formosan Medical Association xxx (xxxx) xxx

Available online at www.sciencedirect.com
ScienceDirect
journal homepage: www.jfma-online.com

Original Article

A multi-disciplinary rehabilitation approach for people surviving severe COVID-19—a case series and literature review

Hung-Jui Chuang [1], Ming-Yen Hsiao [1], Tyng-Guey Wang, Huey-Wen Liang*

Department of Physical Medicine and Rehabilitation, National Taiwan University Hospital and College Medicine, Taipei, Taiwan, ROC

Received 9 November 2021; received in revised form 23 November 2021; accepted 6 February 2022

KEYWORDS
Activities of daily living;
Cardiopulmonary function;
Dysphagia;
Long COVID;
Rehabilitation

Background/Purpose: COronaVIrus Disease 2019 (COVID-19) has caused tremendous casualties and morbidities worldwide. Multisystem manifestations, including muscle weakness, dyspnea, cognitive decline, dysphagia, and dysarthria are frequently reported among critically ill patients. The resultant activity limitations and participation restrictions call for an organized and multidisciplinary approach to rehabilitation. Taiwan had a rapid surge in community infection cases from May to July 2021, and our team established a team-based approach in response to the rehabilitation needs for the in-patients, especially the critically-ill group.
Methods: We built a core treatment team and established a referral pathway for critically ill patients with COVID-19 based on a multidisciplinary approach. The care process and outcomes of a case series of patients who received in-patient rehabilitation after medical stabilization were presented.
Results: Our clinical care module was established according to interim World Health Organization guidance and current research and demonstrated a high degree of feasibility. Five patients with multiple impairments received in-patient rehabilitation and experienced significant functional improvement. We documented improvements in motor function, swallowing function, and activities of daily living after the rehabilitation.
Conclusion: Our clinical experience suggests considerable benefits can be obtained from a well-organized and multidisciplinary rehabilitation approach for severe COVID-19 patients.

* Corresponding author. No 7, Chong-Shan South Road, Taipei, 100, Taiwan, ROC.
E-mail address: lianghw@ntu.edu.tw (H.-W. Liang).
[1] HJC and MYH contributed equally to the article.

https://doi.org/10.1016/j.jfma.2022.02.002

Introduction

The COronaVIrus Disease 2019 (COVID-19), caused by severe acute respiratory syndrome—related coronavirus (SARS-CoV) was first reported in late 2019, and was declared a global pandemic by the World Health Organization (WHO) on 11 March, 2020. As of November 2021, COVID-19 had caused more than 244 million confirmed infections and approximately 5 million deaths.[1] Taiwan managed to keep local infections well controlled until a significant community outbreak in early May 2021 resulted in more than 14,000 new cases and about 800 deaths in five months.[2] Daily confirmed infections peaked near five hundred in late May, but then fell to low double-digits within 2 months. Throughout the surge, National Taiwan University Hospital was a critical response site, and had to respond to the challenge in short order.

COVID-19 presents a broad spectrum of presenting symptoms and disease severity among individuals, from asymptomatic to acute respiratory distress syndrome and death.[3] The proportion of patients who are critically ill or require intensive care ranges from 5 to 20%.[4,5] Many COVID-19 survivors are at risk of long-term impairment and disability, especially critical cases [1]. Severe physical deconditioning frequently accompanies cardiopulmonary, neuropsychological symptoms and other extrapulmonary manifestations,[6,7] resulting in significant impairment to mobility and activity of daily living (ADL) functions. Thus, these patients require multidisciplinary rehabilitation to maximize their functional recovery and facilitate returning to premorbid life.[8]

Rehabilitation can effectively improve functional outcomes for many diseases with established guidelines, including neurological, cardiac disease and pulmonary conditions.[9–11] However, the development of such guidelines requires the accumulation of adequate evidence through well-designed clinical trials, which have yet to be conducted for COVID-19. Therefore, clinical practice must rely on currently available knowledge based on similar medical conditions or clinical experience from observational studies. Taiwan only experienced its first significant COVID-19 outbreak more than a year after the pandemic began, allowing local clinicians to respond quickly to patient needs based on published guidelines and research. This paper shares the Taiwan experience of providing rehabilitation for COVID-19 patients, including the assembly of a core team, establishing clinical pathways and caring for critically ill patients. We also review current studies regarding the characterization of rehabilitation needs and the rehabilitation modules of COVID-19 survivors to improve clinical practices in rehabilitation and facilitate future studies.

Methods

Creating a care team and establishing a clinical rehabilitation path

NTUH is a major university hospital in Taipei, with around 1300 beds for acute care and 150 beds for intensive care. The department of Physical Medicine and Rehabilitation provides consultation to in-patients in the acute care units, in-patient rehabilitation service with 60 beds, and outpatient service. When COVID-19 surged in May, our department assembled a core team to provide rehabilitation services. The team included three physicians, three senior residents, five nurses, three physical therapists, two occupational therapists and two speech therapists. This team established guidelines for the scope of care, referral process and care pathway, along with principles for using personal protective equipment (PPE) based on the recommendations of the World Health Organization (WHO) and our hospital.[12,13] The scope of rehabilitative care included:

1. All COVID-19 cases with exercise intolerance and symptomatically reduced cardiopulmonary function;
2. Critically-ill COVID-19 cases discharged from intensive care units (ICUs) and with activity limitations;
3. Patients with concurrent SARS-CoV-2 infection and recent onset of neurological conditions, such as stroke, spinal cord injuries and brain trauma.

These principles and the referral pathway were relayed to the COVID-19 acute care team (Fig. 1). The team physiatrist first evaluates each patient to determine rehabilitation needs. Team members then reach a consensus for a minimal evaluation set with standardized tools for physicians, physical therapists, occupational therapists and speech therapists. We also produced written materials and videos to communicate essential information to patients.

Admission criteria to the rehabilitation unit:

1. Two consecutive sets of reverse transcriptase polymerase chain reaction (RT-PCR) with negative results or a cycle threshold value exceeding 34 within 7 days;
2. No oxygen requirement greater than 3 liters per minute;
3. Stable vital signs including body temperature, blood pressure, and heart rate;
4. Need for multidisciplinary rehabilitation;
5. Clear consciousness and able to follow up simple orders.

In-patient rehabilitation process

In-patient rehabilitation was organized in a stand-alone space in the ward, with ambulatory oxygen saturation monitoring available for each patient. In-patient rehabilitation services continued for patients with stroke, spinal cord injuries or traumatic brain injuries, but with around 70% of the usual caseload. All COVID-19 patients received physical therapy (PT) and occupational therapy (OT), while some also received speech therapy (ST) and psychological assessments as clinically indicated. Each treatment session lasted at least 20 minutes per day, 5 days a week, as tolerated. Oxygen saturation was monitored during treatment. The PT program included motor strengthening, balance training, aerobic training and ambulation training according to patient ability. Outside treatment sessions, patients were instructed in individualized, low intensity and multiple repetition exercises with the aid of videos or pictures. Patients were also instructed in breathing exercises to relieve exertional dyspnea and control inspiratory/expiratory rhythm. Meanwhile, OT focused on skill training

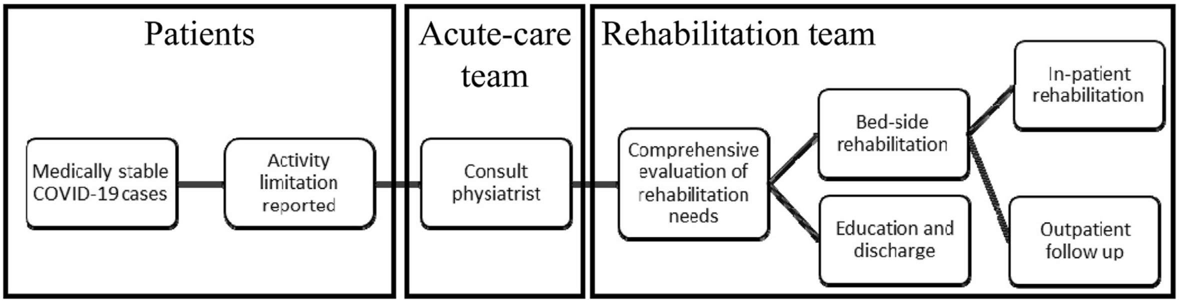

Figure 1 Rehabilitation referral pathway of COVID-19 patients at NTUH.

for basic activities of living (bADLs), along with energy-saving principles, evaluation of adaptive devices and environmental checkup for discharge preparation. ST was prescribed if there was risk of choking or slurred speech, with complementary fiberendoscopic evaluation of swallowing (FEES) or videofluoroscopic swallowing study (VFSS) based on clinical evaluation.

Discharge goals were individualized according to the patient's ability and expectations, along with the rehabilitation team's evaluation. Electronic medical records (EMR), a bi-weekly web-meeting and an online message board were used to track the rehabilitation progress, promote team communication and dynamically adjust rehabilitation goals, with process stakeholders including patient family, a case manager for discharge planning and social workers. Clinical data for all COVID-19 patients admitted to our rehabilitation units between May 1st and September 30th, 2021 were reviewed retrospectively for one patient and collected prospectively for four patients. The study was approved by the research ethics committee of the National Taiwan University Hospital (approval no: 202106073RINB, date: 14 July, 2021) and accorded with the Helsinki Declaration of 1975, as revised in 2000.

Results

Five cases were admitted to the PMR ward for in-patient rehabilitation (Table 1). They were mostly elderly and all received oxygenation during the acute disease stage, and two were intubated. All were hospitalized for an extended duration, with a median ICU stay of 17 days. All had at least one of the chronic conditions, and two of them were being treated with corticosteroids before SARS-CoV-2 infection for systematic lupus erythematous and chronic obstructive pulmonary disease. With the exception of a single patient with morbid obesity before COVID-19 onset, all had a body mass index (BMI) below 19 (15.3–18.2) kg/m^2.

Initial evaluation on admission showed some common problems, including general weakness, dyspnea and hypoxemia at rest and exertion, difficult walking and inability to manage bADLs independently. Patient's weakness was generally mild and non-focal, with three patients having scores between 36 and 48 according to Medical Research Council sum score (MRC-SS) or dynanometric grasping power below 11 kg. Some additional problems were identified in some patients, including depression, mild to significant cognitive impairment, dysphagia, limb numbness and difficult urination.

All patients received PT, OT and ST. For two patients, ST was prescribed to help reduce slurred speech and poor eating endurance because of dyspnea. All were under low-dose corticosteroid treatment through hospitalization. One patient had severe anxiety and depression, which required medication and help from a psychologist. One patient with premorbid dementia had significant delirium upon admission, which improved after medication with Quetiapine. Nerve conduction studies were performed in four patients because of limb numbness. Three examination results were compatible with a polyneuropathy with predominantly axonal degeneration and one other result was compatible a motor-predominant mononeuropathy multiplex. One patient received FEES, which showed post-swallow residue in vallecula and piriform sinus, delayed swallowing response and diminished laryngeal motor response, but did not disclose vocal cord palsy.

Patients were hospitalized for 11–44 days, with a median hospitalization of 17 days. Two patients required low-flow (0.5 L/min) oxygenation during daily activity. Before discharge, all patients were ambulatory and showed significant improvement in bADL function. All tubes were removed successfully. Four were discharged home and one was sent to a nursing home.

Discussion

Taiwan had managed to keep domestic COVID-19 case numbers low until a surge in May 2021. Our rehabilitation team assembled quickly in response to address the emerging clinical need, while maintaining usual care for in-patient rehabilitation. This effort was facilitated by referencing the cumulative clinical experience of other countries responding to their own COVID-19 outbreaks. Previous studies have found that well-organized multidisciplinary rehabilitation is essential to restoring the function of critically ill COVID-19 patients, including a personalized rehabilitation and management plan that encompasses comprehensive assessment, goal setting and coverage of all symptoms.[15] Although the evidence-based guidelines for rehabilitation following COVID-19 are yet to be established, the general consensus is that rehabilitation should be an integrated component of care, based on a patient-centered multidisciplinary team approach with individually tailored treatment plans according to the patient's specific characteristics, functional status and disease stage.[16–20] The following sections discusses our clinical eperience and presents a comprehensive review.

Table 1 Clinical features of five cases.

Case	1	2	3	4	5
Sex/age	Female/64.2	Male/84.4	Male/74.7	Male/88.8	Male/55.1
Body height (cm)	165	158	165	161	172
Body weight initial/ discharge (kg)	45/41.7	55/43.0	50/49.7	58/42.4	95.4/90.8
BMI initial/discharge (kg/m^2)	16.5/15.3	22.0/17.2	18.4/18.2	22.4/16.4	32.2/30.7
Comorbidities	DM, SLE, RA, CAD	DM	COPD	Asthma, hypertension, dementia	DM, hypertension, obesity
Ventilation aid	HFNC, biPAP	HFNC	HFNC	IMV, HFNC	IMV, HFNC
Severity scale[14]	5	5	5	6	6
Days to first rehabilitation consultation	65	54	64	92	25
Days to negative PCR[a]	56	NA[a]	55	67	24
ICU stay days	26	NA[a]	12	39	17
Days before admission to rehabilitation units	76	72	71	92	32
Tube	nasogastric tube, Foley tube	Nil	Nil	nasogastric tube	Nil
Nerve conduction studies	polyneuropathy, axonal type	polyneuropathy, axonal type	motor-predominant mononeuropathy multiplex	polyneuropathy, axonal type	—
Rehabilitation stay (days)	44	11	17	27	12
Barthel Index score on admission	15	15	40	0	60
Barthel Index score before discharge	65	80	75	40	95
FAC on admission	1	2	2	0	3
FAC upon discharge	3 (with nasal canula 0.5 l/min and a unicane)	4 (with a unicane)	4	2 (with a unicane and contact guard)	4
FOIS on admission	1	6	6	1	7
FOIS upon discharge	6	6	7	6	7

NOTE: BiPAP = Bi-phase positive airway pressure, BMI = body mass index, CAD = coronary artery disease, COPD = chronic obstructive pulmonary disease, DM = diabetes mellitus, FAC = functional ambulation category, FOIS = functional oral intake scale, HFNC = high flow nasal cannula, IMV = invasive mechanical ventilation, RA = rheumatoid arthritis, SLE = systematic lupus erythematous.
NOTE.
[a] Transferred to our hospital after negative PCR.

Multidisciplinary approach for in-patient rehabilitation

Early intervention is a key component for neuro-rehabilitation.[9] The UK's National Health and Care Excellence (NICE) scheme recommends early initiation of rehabilitation in the post-acute stage, preferably within the first 30 days, to maximize functional recovery and prevent complications and physical deconditioning.[21] Nonetheless, the patients presented in this study received their rehabilitative assessment mostly after 30 days. This time lag is related to our internal principle of starting rehabilitation service only after medical stabilization, thus a delayed approach was adopted for severely ill patients due to their complicated course of treatment. For less severe patients, our care pathway could still provide early intervention, even when PCR results are still positive. This was aided by the use of appropriate PPE and video-based communication.

These severely ill patients had multiple functional deficits, requiring a comprehensive and multidisciplinary approach to meet their rehabilitation needs. They also had concurrent risk factors associated with severe illness and functional decline, such as old age, pulmonary disease, diabetes and obesity.[22] To provide multidisciplinary rehabilitation, our core team was comprised of physicians, nurses, physical therapists, occupational therapists, and speech therapists. In addition, we collaborated with other specialists, such as infection specialists, pulmonologists, psychiatrists, social workers and dietitians. This approach was based on a prospective cohort study of post-acute severe to critical COVID-19 patients. The team implemented a multi-disciplinary evaluation and therapy approach including physiotherapists, psychologists, psychiatrists, internists, pulmonologists, cardiologists, and neurologists.[23] A team-based care module can be built according to clinical needs, but required efficient team communication through electronic message boards within EMR systems, web-meeting and online tools.

The care pathway was established according to interim WHO guidance,[24] which provided a feasible framework for use within our institution. The core team was effective in building consensus, promoting education and training, communicating, and providing standardized care. Rehabcycle, with International Classification of Functioning, Disability and Health and related tools, is recommended to facilitate multidisciplinary and patient-oriented rehabilitation management,[25] including for COVID-19 patients.[12] Health conditions and rehabilitation needs can change during the treatment course, and outcome measurements should cover a wide range of functional deficits in COVID-19 patients. As recommended by the WHO and other experts, we found it helpful for the pre- and post-rehabilitation assessments to include at least vital signs, important disease-related laboratory data, pulmonary function, subjective fatigue, dyspnea, pain, joint and muscle function, mobility, swallowing, cognitive impairment, mental health, and activity level.[12,19] However, some of commonly used outcome measurements might have an initial floor effect for severe cases, such as 6-min walking test (6MWT) or sit-to-stand. We also found that the impact of post-infection impairments sequels and the pre-existing disabling conditions were both important considerations for planning and goal setting. Therefore, individualized rehabilitation plans should be tailored to the patients' health conditions, functional characteristics, and unmet rehabilitation needs.

There is increasing evidence of the effectiveness of intensive inpatient rehabilitation for COVID-19 patients.[8,26] Our patients received a median of 17 days of inpatient rehabilitation, consisting of at least 20 min of regular PT and OT per day, 5 days a week, and needs-based ST sessions. All patients showed improved Barthel Index (BI) scores of at least 35 and all tubes were removed upon discharge with Functional Oral Intake Scale scores of 6–7. Positive results regarding ADL function, muscular strength, endurance and swallowing function were reported in two retrospective reviews of COVID-19 patients admitted for post-acute rehabilitation with similar training intensities and durations.[8,26] Notably, as in other case series, the patients still exhibited residual deficits at discharge, including poor endurance and imbalance, highlighting post-acute care needs after discharge from in-patient rehabilitation units.

Pulmonary sequelae

Exercise intolerance and dyspnea were among the most frequent complaints and the main limiting factors for daily functions in our patients. The pulmonary system is the primary target of SARS-CoV-2 infection, and mechanisms of lung injury after SARS-CoV-2 infection include epithelial injury via direct viral invasion as well as damage due to excessive immunological response, causing diffuse alveolar injury and even fibrotic change in lung tissue.[27] After short-term inpatient rehabilitation, the ambulation function and exercise tolerance improved significantly in all our patients. By discharge, 2 out of the 5 patients still needed supplemental O2 during activity to sustain a SpO2 level >90%. Persistent hypoxemia with supplemental oxygen demand was common in COVID-19 survivors, with demand positively correlated with disease severity.[28,29]

Pulmonary rehabilitation has been used in patients with chronic lung disease to reduce symptoms, while improving functional capacity and quality of life. There are several consensus-based guidelines suggesting a pulmonary rehabilitation program tailored to individual COVID-19 survivor needs.[16,30–32] A pulmonary rehabilitation program usually consists of patient education, psychological support, lifestyle modification and exercise training including aerobic exercise, resistance training and respiratory training.[16] Previous experience with SARS-CoV-1 infection showed improvement in the 6MWT, lung function, musculoskeletal performance and quality of life after exercise intervention.[33–35] The optimal rehabilitation model, dosage, or intensity in patients after SARS-CoV-2 infection remains unknown, and we followed general principles in starting from light intensity, with incremental intensity increase based on the patient's clinical features.

Muscle weakness

General but mild weakness was noted in all our patients. The weakness in the severe COVID-19 cases is similar to ICU-acquired weakness (ICUAW), with typical features such as generalized and symmetrical weakness with a greater impact on proximal rather than distal limb muscles.[36,37] Up to 72% of critically ill CoVID-19 patients required invasive mechanical ventilation initially at awaking,[38] and 44% of the weak patients were unable to walk 100 m 30 days after weaning.[39] Those patients with weakness tend to have lower BI scores, higher disability and a high referral rate for in-patient rehabilitation.[36,38]

Muscle weakness is multifactorial and a direct consequence of the viral infection, SARS-CoV-2 infection related neurological complications and adverse effects from treatment.[40] Malnutrition, social isolation, and prolonged immobilization have further negative impacts on sarcopenia and physical deconditioning.[41] We identified several contributing factors in the reported patients, including prolonged immobilization, uses of corticosteroids and coexisting peripheral neuropathy. Sarcopenia was also likely, since four patients had BMI values between 15 and 18 kg/m^2. However, none reported muscle pain, which was one of the clinical presentations of skeletal muscle injuries due to the autoinflammatory process of COVID-19.[42,43]

ICUAW diagnosis is based on manual muscle testing with MRC-SS, the handgrip dynamometry test and electrodiagnosis.[44,45] The former two tests, along the physical functional tests, help to assess the severity of muscle weakness. Three of the reported patients fulfilled the criteria of significant weakness according to the MRC-SS and grasping power.[46,47] Four underwent nerve conduction studies, which were compatible with a polyneuropathy or mononeuropathy multiplex. Notably, two patients had diabetes mellitus, which contributed to neuropathy.

There are currently no established guidelines for the rehabilitation for muscle weakness after severe COVID-19, including intervention type, timing and dosage. General principles for strengthening are providing short, low-intensity and repeated as tolerable exercise given their compromised cardiorespiratory condition and high levels of fatigability.[8] We followed these principles and provided video or hard-copy materials to facilitate in-patient and post-discharge rehabilitation.

Dysphagia

Two of our patients had significant dysphagia upon admission. Both were admitted to the ICU for more than 3 weeks, and one was intubated for more than a month. COVID-related dysphagia occurs in 20–29% of hospitalized patients[48,49] and 86% of post-intubation patients.[26] The prevalence is as high as 90–96% in critically ill COVID-19 patients, as detected by FEES or VFSS.[50,51] The pathophysiology of COVID-19-related dysphagia is postulated as resulting from related muscle injury, critical illness polyneuropathy and myopathy, and central nervous system complications,[52] while intubation related trauma, impaired laryngeal sensation, and desynchronization of breathing and swallowing may all play a role.[53] Consistent with these observations, FEES in one of our patients showed characteristics indicative of a mixed etiology rather than direct intubation-related trauma. In post-extubation COVID-19 patients, vallecular stasis occurred in 27% and piriform sinus stasis in 7% as detected by VFSS.[54] Another VFSS study reported delayed pharyngeal phase, premature oral leakage, reduced tongue base retraction, impaired laryngeal closure and pharyngeal contraction as the most frequent findings. Penetration or aspiration occurred in 76% and all but one were silent.[51] A FEES study showed pooling of secretions in 92%, and silent aspiration in 44% of ICU COVID-19 patients. All patients had vallecula and hypopharynx residue and 76% had impaired vocal cord movement.[50]

The swallow evaluation of COVID-19 patients comprises a formal screening,[55–57] clinical bedside examination[58,59] and instrumental exam as needed.[53] Rehabilitation should focus on improving patients' lung function, secretion management, nutrition, and oral hygiene. Compensatory strategies and restorative exercise enables early oral intake while reducing aspiration risk.[48,60] All of our patients achieved FIOS 6–7 before discharge, indicating a high potential for recovery.

Neuropsychiatric consequences

Two of our patients had significant neuropsychiatric impairments, one with anxiety and depression while the other suffered from delirium with significant cognitive impairment. These symptoms hampered the rehabilitation process and required medication. Common neuropsychiatric sequelae after SARS-CoV-2 infection includes fatigue, sleep problems, anxiety, depression, post-traumatic stress disorder, headache, delirium, and cognitive impairment,[61–65] with lasting insomnia, depression/anxiety in 10%–30% of patients for 60 days or longer. The severity of SARS-CoV-2 infection is positively associated with the incidence of neurological and psychiatric morbidities.[66] Of a large cohort of 2088 ICU patients, 55% were delirious for a median of 3 days.[67] Cognition deficits are seen in up to 80% of severe cases and last for months, with long-term negative impacts on functional outcomes and daily activity.[68,69] Therefore, a comprehensive neuropsychological evaluation and follow-up might be indicated for COVID-19 survivors. We included Mini-Mental State Examination and Montreal Cognitive Assessment in our assessment, but a comprehensive evaluation by an occupational therapist or a psychologist should be available if clinically indicated. In addition, cognitive rehabilitation and caregiver education should be incorporated into practice to facilitate the recovery of cognitive function as well as provide compensatory strategies to enhance independence in daily activities.

Conclusion

In conclusion, COVID-19 survivors are at risk of multi-system impairments, which compromise functional abilities and quality of life. COVID-19 rehabilitation needs to address cardiorespiratory and motor deconditioning, along with neurologic and cognitive deterioration, aggravation of comorbidities, and consequences of prolonged bed rest.[8,70] Specific data for rehabilitation needs and the effects from rehabilitative intervention are urgently required. Rehabilitative intervention should be initiated as early as suitable in critically ill cases to prevent secondary complications, retard physical deconditioning, and facilitate returning to premorbid ADL function. A well-organized and multidisciplinary inpatient rehabilitation program can achieve a functional improvement in severe COVID-19 patients. Moreover, long-term follow up and outpatient or community-based rehabilitation is necessary to manage persistent symptoms after discharge.

Declaration of competing interest

The authors have no conflicts of interest relevant to this article.

Acknowledgements

This work was supported by the National Taiwan University Hospital (grant numbers 111-N0086).

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