Pulmonary Rehabilitation of a Critically Ill Patient with Severe COVID-19: A Case Report

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ABSTRACT

Coronavirus 19 disease (COVID-19) is an infectious disease caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). This is a case of a previously healthy 61-year-old man who presented to the emergency department with progressive dyspnea and a confirmed COVID-19 test, who was critically ill with severe acute respiratory distress syndrome. The principles of pulmonary rehabilitation were implemented starting from the sixth hospital day (time of referral from the intensive care unit) until he was transferred to a non-COVID ward and discharged. The patient participated in six treatment sessions while admitted, with each session lasting nearly 30 minutes. His Barthel index score improved from 0 (total dependence) to 85/100 (modified independence), with improvements in pulmonary secretions, shortness of breath, rate of perceived exertion, muscle strength, and endurance. He was able to return to work after three months. The application of the principles of pulmonary rehabilitation for critically ill patients with severe COVID-19 helped improve the cardiopulmonary, cognitive, and functional aspects of the patient throughout the course of hospital admission and beyond discharge.

Key Words: COVID-19, critical illness, intensive care unit, rehabilitation, pulmonary rehabilitation

INTRODUCTION

The continuing coronavirus disease 2019 (COVID-19) pandemic presents significant challenges to the medical and rehabilitation communities. COVID-19 is an infectious disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) that results in respiratory and multisystemic manifestations.[1] While the majority of infected individuals present with mild or no symptoms, a significant number of patients may become critically ill with severe COVID-19, necessitating mechanical ventilation (MV) and medical support in an intensive care unit (ICU).[2,3] Mechanically ventilated patients are at an increased risk of developing physical and psychological complications associated with prolonged weaning from MV. These complications may include ICU-acquired weakness, delirium, and loss of physical function that can persist well beyond ICU and hospital discharge.[4] Severe respiratory failure is a likely cause of mortality among patients with COVID-19-related acute respiratory distress syndrome (ARDS).[5]

Several studies show that early rehabilitation during the acute stage of critical illness may result in decreased duration of MV, reduced length of stay in the ICU, and improved mobility, exercise capacity and functional status.[6-8] With the lack of reports and absence of guidelines on the rehabilitation of critically ill patients with severe COVID-19, it is reasonable to hypothesize that early pulmonary rehabilitation during the acute stage of severe COVID-19 may have beneficial effects. However, the highly contagious

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nature of the disease, lack of available effective treatment, and limited supply of personal protective equipment (PPE) present considerable challenges to the implementation of in-person rehabilitation sessions. The purpose of this case report is to describe the application and benefits of the principles of pulmonary rehabilitation on an older critically ill adult with severe COVID-19.

CASE

A 61-year-old man with a ten-day history of cough and fever (maximum temperature: 39 degrees Celsius) tested positive for COVID-19 on reverse transcriptase-polymerase chain reaction test (RT-PCR) for SARS-CoV-2 two days prior to admission. Before admission, he was independent in activities of daily living (ADL), worked as an electrical engineer, and lived with his wife and children. His past medical history included chronic hypertension with good control. At the emergency department, he presented with progressive dyspnea (respiratory rate: > 30 breaths per minute) and hypoxemia (oxygen saturation: 50% at room air). Chest radiograph showed > 50% affectation with diffuse alveolar and bilateral interstitial infiltrates (Figure 1). He was hooked to a mechanical ventilator. With his

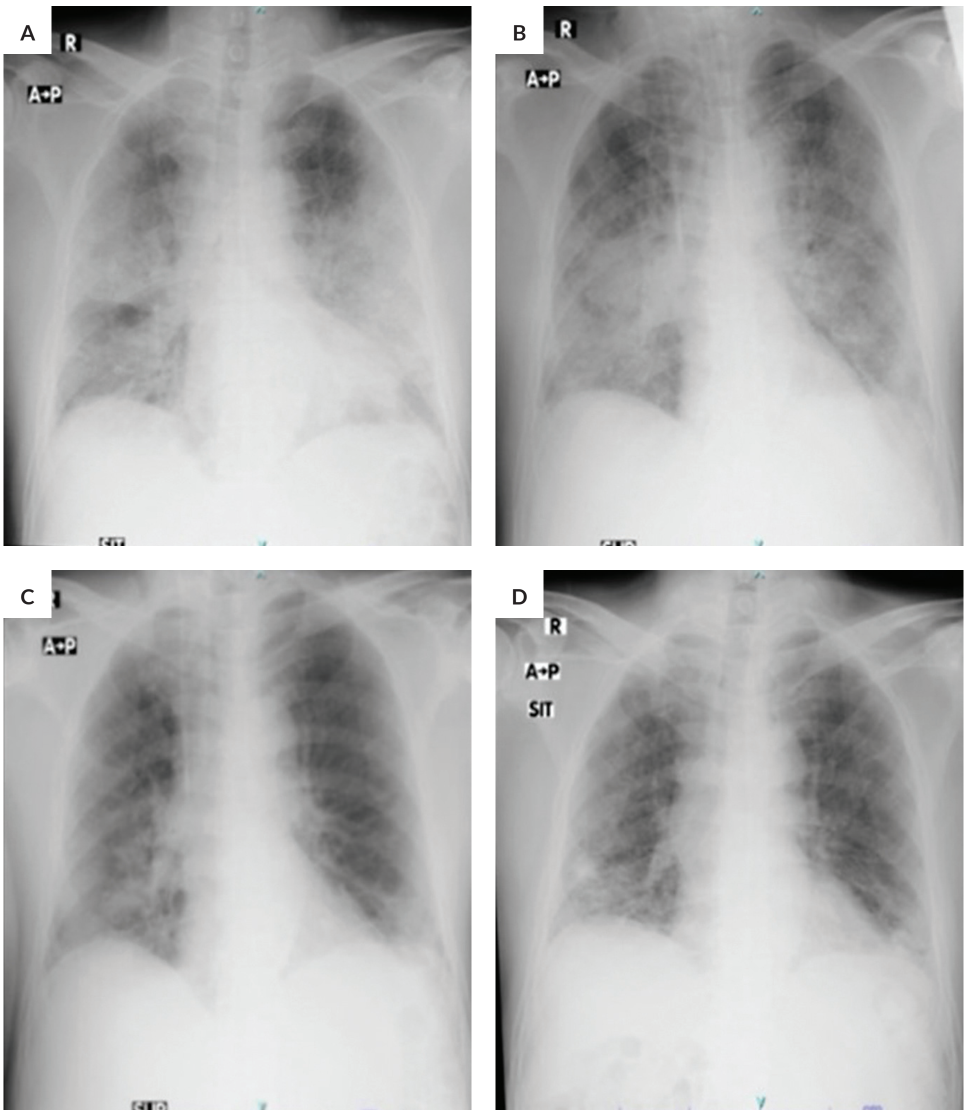

Figure 1. Monitoring of chest X-ray findings during hospital admission. **(A)** Chest X-ray upon admission showed peripheral ground glass opacity (GGO) in the upper, middle, and lower zones on the right lung, and lower zone on the left. **(B)** Chest X-ray obtained on the 4th hospital day showed regression of GGO. **(C)** Chest X-ray obtained on the 8th hospital day showed further regression of GGO. **(D)** Chest X-ray obtained on the 12th hospital day showed clearing of GGO.

clinical presentation and initial laboratory results (elevated anti-inflammatory markers, elevated liver enzymes, hypercoagulability state, and acute respiratory failure), he fit in the critically ill, severe category of COVID-19 with encephalopathy, probably hypoxic versus septic. He was also found to have hyponatremia and hypochloremia from poor oral intake. The following medications were started: meropenem 1 g intravenously (IV) every 8 hours; dexamethasone 6 mg IV once a day for 10 days; remdesivir 200 mg as loading dose, followed by 100 mg daily for 5 days; tocilizumab 400 mg IV given via 2-hour infusion for 2 days; and omeprazole 40 mg powder for solution for infusion.

On the 3rd hospital day (HD), he was transferred to the COVID ICU, sedated with Richmond Agitation-Sedation Scale (RASS) score ranging from –2 to –4. He had elevated systolic blood pressure at 140 mmHg and no febrile episode.

On the 4th and 5th HDs, his nasogastric tube (NGT) showed coffee ground blood-tinged secretions, requiring referral to a gastroenterologist. He was diagnosed with upper gastrointestinal bleeding from stress-related mucosal injury. An increasing trend in liver enzymes was also noted. Omeprazole drip was continued, and rebamipide 100 mg/tab every 8 hours was started.

On the 6th HD, he was referred to Rehabilitation Medicine. Remote screening was initially done, consisting of a review of the patient's electronic medical record (EMR) via the hospital's computerized registry of admissions and discharges (RADISH), and phone calls with the nurse in charge, relaying the patient's level of consciousness and trends in hemodynamic, oxygenation and mobility status.

Initial Examination

A comprehensive physiatric assessment was then performed in-person (Table 1). The patient was seen sedated (RASS score of –3) on moderately elevated back rest, hooked to MV via an endotracheal tube (ETT), with a 2-point upper extremity restraint due to episodes of agitation and attempts of self-extubation. His vital signs were stable

Table 1. Course of inpatient rehabilitation

	Intensive Care Unit		Regular Ward			
	HD 6 Rehab D1	**HD 7 Rehab D2**	**HD 9 Rehab D4**	**HD 14 Rehab D9**	**HD 18 Rehab D13**	**HD 20 Rehab D15**
Vital Signs	SBP 147-152 DBP 89-100 HR 79-97 RR 16-18	SBP 149-166 DBP 90-103 HR 90-103 RR 15-25	SBP 130-150 DBP 70-90 HR 94-111 RR 21-23	SBP 119-124 DBP 60-90 HR 88-108 RR 20	SBP 90-110 DBP 65-80 HR 85-95 RR 19-21	SBP 90-110 DBP 65-80 HR 85-95 RR 16-20
Mental State	Off sedation; RASS -3	RASS -1 to 0	Lethargic	Alert		
Breathing	Intubated on spontaneous mode	Extubated; FM at 10 Lpm	FM at 10 Lpm; 98% O_2	FM at 6-8 Lpm; 96% O_2; SOB in standing	Tolerated room air; SOB in ambulation	(-) SOB
Speech	Not assessed	(+) dysphonia	(-) impairment			
Swallowing	On NGT		NGT removed	Oral feeding	Oral feeding	Oral feeding
RPE	Not assessed		3-4	3-4	2-3	1-2
Mobility	Bedbound		Tolerated high backrest	SOB in standing	SOB in ambulation	(-) SOB
Rehab Goals	To mobilize secretions		To improve pulmonary function	To reduce work of breathing	To reduce dyspnea	To improve cardiopulmonary endurance
Rehab Strategies	Chest Physiotherapy • Postural drainage (e.g., positioning) • Mobilization of pulmonary secretions • Breathing exercises • Effective coughing techniques • Chest expansion exercises		Exercises • Range of motion exercises for both upper and lower extremities • Strength training of proximal muscles for both upper and lower extremities • Balance training initially from sitting to standing (static to dynamic) ADL Modification • Stress-relieving positions/ posture • Proper ergonomics • Training for bed mobility, transfers, transitions, and ambulation (initially with an assistive device)			Exercises • Progressive resistance training • Aerobic conditioning based on computed target HR

Red-colored boxes indicate the time when the patient had severe impairments; yellow boxes indicate moderate impairments; and green box indicates mild impairments.

HD, Hospital day; Rehab D#, Rehabilitation day; SBP, Systolic blood pressure (mmHg); DBP, Diastolic blood pressure (mmHg); HR, Heart rate (beats per minute); RR, Respiratory rate (breaths per minute); RASS, Richmond Agitation-Sedation Scale; FM, Face mask; Lpm, Liters per minute; O_2, Peripheral oxygen saturation; SOB, Shortness of breath; NGT, Nasogastric tube; RPE, Rate of perceived exertion on Modified Borg Scale; ADL, Activities of daily living as follows: blood pressure of 140/90 mmHg; heart rate of 90 beats per minute; respiratory rate of 16 breaths per minute; and peripheral oxygen saturation of 98%.

He had anicteric sclerae, pink conjunctivae, no neck vein engorgement, with an intrajugular vein catheter on the right, and clear output per NGT. He had symmetric chest expansion, crackles on both lung fields, and unremarkable heart and abdominal findings. He had indwelling foley catheter, full and equal peripheral pulses, intact capillary refill, without peripheral edema or any pressure injury. The extremities were normotonic with no guarding or limitation of motion on passive movement.

Clinical Impression

COVID-19 is a novel disease, but the medical and functional problems observed in the patient are similar in critical illness due to other causes. Given the evidence supporting the beneficial effects of ICU-based rehabilitation on pulmonary, cognitive, and physical functions in these populations, rehabilitation medicine services are indeed warranted to help improve breathing, mental state, functional mobility, and ADL. In the study institution, patients in the ICU commonly received in-person therapy for five days per week before the COVID-19 pandemic. However, amid the limited PPE and manpower during the pandemic, the frequency of physical therapy sessions was reduced to 2–3 days per week in compliance to the COVID-19 prioritization guidelines of the Department of Rehabilitation Medicine.

Change in Medical Status

On the first rehabilitation day, the patient tolerated off-sedation with no agitation episode, hooked on MV via ETT. Bedside physical therapy (PT) session consisted of chest physiotherapy (pulmonary drainage, chest clapping/vibration, passive mobilization of extremities on moderate back rest elevation) with no untoward events noted. On the following day, he was extubated from MV and hooked to oxygen support via face mask at 10 liters per minute (Table 1).

The patient had two days of PT sessions in the ICU that focused on chest physiotherapy to mobilize pulmonary secretions before transfer to the regular ward. He did not present with cognitive dysfunction and was noted to have gradual improvements in chest radiograph findings (Figure 1), laboratory parameters, and medical condition. In the regular ward, the patient tolerated gradual weaning from oxygen support, and progression of therapeutic exercises. The vital signs and the rate of perceived exertion (RPE) were regularly monitored.

On the ninth rehabilitation day, the patient tolerated standing with support, initially with shortness of breath (SOB) during transition from supine to sitting or standing with a walker. The RPE was reported to be 3–4 (moderate to somewhat hard) on Modified Borg Scale. As standing tolerance improved, dynamic activities were incorporated in the rehabilitation program to improve balance and lower limb strength. He was able to ambulate from the bed to the bathroom with minimal assistance by the 13th rehabilitation day (Table 1). He was discharged with noted functional improvements, and recommended to continue physical therapy at home via telerehabilitation.

In preparation for hospital discharge, the patient was trained on self-monitoring of vital signs (blood pressure, pulse rate, respiratory rate) and RPE. He also received patient education on activity pacing and energy conservation. At home, he underwent remote or online-based physical therapy sessions through telerehabilitation for 30 minutes every other day to improve physical function, mobility, and endurance. The telerehabilitation sessions focused on moderate-intensity functional activities (transitions, transfers, standing, ambulation) with rest breaks as needed and careful monitoring of the patient's vital signs, breathing (pacing with activity), and indicators of fatigue like declining movement quality.

Outcome and Follow-up

The patient was weaned off from MV on the 2nd rehabilitation day. By the 4th rehabilitation day, he exhibited clinical improvements in cognition, breathing, speech, swallowing, and mobility. His functional level improved from a Barthel Index score of 0/100 (total dependence) to 85/100 (full independence).[9] He eventually achieved ambulation over 100 feet with supervision and no assistive device. The patient seemed to be highly motivated to return to his prior level of function. Continued outpatient rehabilitation was recommended upon discharge to further improve his cardiac, pulmonary, and physical function via telerehabilitation. Daily the patient recorded his vital signs, symptoms (SOB, cough, muscle pain), and RPE. A carefully paced telerehabilitation program with a remote physical therapist was implemented, beginning with low-intensity, low-repetition, and short-duration exercises.

Two weeks post-discharge, there were no reports of SOB, cough, or muscle pain. He was compliant with his daily exercise regimen including breathing and resistive exercises, as well as ambulation training for > 30 minutes.

Four weeks post-discharge, the patient remained asymptomatic. He went back to driving and resumed work as a self-employed electrical engineer. He also returned to the gym for resistive and aerobic exercises.

Two months post-discharge, the patient's course remained unremarkable. He continued to exercise daily with noted progress in his lifting capacity (e.g., bench press [80 lbs.] for 10 repetitions x 4 sets; triceps push-down [20 lbs.] for 10 repetitions x 4 sets; body-weight squats for 16 repetitions x 3 sets). He also worked on his cardiovascular endurance through stationary biking for 15–30 minutes. Daily vital signs and RPE were within normal limits, and he was compliant with his follow-up visits with his other doctors.

DISCUSSION

With the lack of reports and absence of guidelines on the rehabilitation of critically ill patients with severe COVID-19, the principles of pulmonary rehabilitation were individualized for this older adult patient. Pulmonary rehabilitation (PR) is defined by the American Thoracic Society / European Respiratory Society (ATS/ERS) as a comprehensive intervention based on a thorough patient assessment, followed by patient-tailored therapies that include, but are not limited to, exercise training, education, and behavior change. These are designed to improve the physical and psychological conditions of people with chronic respiratory disease and to promote the long-term adherence to health-enhancing behaviors.[10] The intervention should be individualized to the unique needs of the patient, based on initial and ongoing assessments, including disease severity, complexity, and comorbidities. Although PR is a defined intervention, its components are integrated throughout the clinical course of a patient's disease.

The progressive deconditioning associated with inactivity initiates a vicious cycle, with dyspnea becoming problematic at even lower physical demands. PR aims to break this cycle. Integrated into the individualized treatment of each patient, PR may reduce symptoms, optimize functional status, increase physical activity, improve the quality of life, and reduce healthcare costs by stabilizing or reversing the systemic manifestations of the disease.[11-13]

PR is a combination of physical exercises and self-management strategies. The nature and intensity of each strategy may vary depending on the individual's exercise response, stage of the disease, and comorbidities. Exercise derives much of its significance when one considers the anxiety-shortness of breath cycle generated by physical inactivity.[7] It consists of conditioning, breathing retraining, education, and psychological support.[12]

The highly contagious nature of COVID-19, the limited PPE and manpower, anxiety among rehabilitation providers rendering inpatient services in COVID zones, and limited duration of rehabilitation treatments are among the challenges in the early phase of implementation of the rehabilitation program. Nonetheless, these were addressed through proper planning, prioritization, time and resource management, and creative strategies. These included providing brochures for patients as additional resource materials about safety protocols (e.g., PPE, vital signs monitoring) and specific exercises. During telerehabilitation sessions (online consultation and therapy services), a computer or mobile device with videoconferencing software, stable internet connection, and consent and participation of the rehabilitation provider/s and patient with or without a caregiver are established prerequisites to the virtual encounter.[14]

With regular follow-up visits through telerehabilitation, patient education was reinforced to improve adherence to healthy lifestyle choices (nutrition, exercise, health maintenance, behavioral strategies). Remote assessment was challenging as virtual means could not fully enable "physical examination" of the patient. Nonetheless, proper patient education on RPE, vital signs monitoring, and detection of clinical signs of fatigue aided in the virtual encounters. Indeed, the active participation of patients and caregivers is necessary to ensure success in every step of the rehabilitation course.

CONCLUSION

Although traditionally pulmonary rehabilitation is for patients with chronic obstructive pulmonary disease, applying its principles may be beneficial for an older critically ill adult with severe COVID-19. With proper planning, prioritization, and time and resource management, an effective and safe in-person pulmonary rehabilitation program can be implemented in the early phase of COVID-19 in the ICU and COVID zones. Early rehabilitation intervention prevents onset of deleterious effects of deconditioning. Regular follow-up visits and therapy sessions upon discharge through telerehabilitation may ensure carry-over and progress of treatment gains amid the distance and enduring COVID-19 pandemic.

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Statement of Authorship

Both authors contributed in the conceptualization of work, acquisition and analysis of data, drafting and revising and approved the final version submitted.

Author Disclosure

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