TITLE: Acute Rehabilitation of a Patient With COVID-19 Myocarditis: A Case Report

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Objective: The purpose of this case report is to describe the acute rehabilitation of an individual with severe COVID-19 complicated by myocarditis, focusing on both facility-wide and patient-specific strategies.

Methods: A 50-year-old male presented to the emergency department with progressive dyspnea and confirmed COVID-19. He developed hypoxic respiratory failure and heart failure, requiring prolonged mechanical ventilation. Mobility was limited by severe impairments in strength, endurance, balance, and cognition. The referral, screening, and rehabilitation of this patient was guided by a COVID-19 Service Delivery Plan designed to maximize the effectiveness and efficiency of care delivery while minimizing staff exposure to the virus. Coordinated physical and occupational therapy sessions focused on progressive mobility and cognitive retraining. Progress was monitored using a series of standardized outcome measures, including the Activity Measure for Post-Acute Care (AMPAC), Timed “Up and Go” (TUG), and the Saint Louis University Mental Status (SLUMS) examination.

Results: Rehabilitation was initiated on day 18, and the patient participated in 19 treatment sessions, each approximately 30 minutes, over the remaining 30 days of his hospital stay. His AM-PAC mobility and function scores both improved from 100% to 0% disability, he experienced substantial improvements in both TUG (Δ = 4.2s) and SLUMS (discharge score =

25), and there were no adverse events. He was discharged to home with his family and home rehabilitation services.

Conclusion: COVID-19 contributed to severe declines in mobility and function in this middle-aged man. He experienced substantial gains in his function, mobility, and cognition during his in-hospital rehabilitation, which was guided by a facility-wide plan to prevent virus transmission.

Impact: The rehabilitation of individuals with severe COVID-19 presents significant challenges, both at the level of the individual patient and the whole facility. This report describes clinical decision making required to manage these individuals in the setting of a global pandemic.

[H1] BACKGROUND AND PURPOSE

The ongoing COVID-19 pandemic presents significant challenges to the United States healthcare system,[1] including the physical (PT) and occupational therapy (OT) professions. While many infected individuals present with mild or no symptoms,[2-4] a significant portion become critically ill with severe COVID-19.[3] Acute Respiratory Distress Syndrome is the leading cause of death in COVID-19, but the immune response triggered by the virus can result in a hyper-inflammatory state, or "cytokine storm",[5] damaging other organs such as the heart[6] and the brain.[7]

The multi-system impact of severe COVID-19 suggests that affected individuals are likely to have significant rehabilitation needs, but few reports focus on rehabilitation for COVID-19.[8-10] Several studies have demonstrated the importance of rehabilitation during critical illness, which is associated with reduced length of stay and improved mobility.[11,12] Thus, it is reasonable to hypothesize that in-hospital rehabilitation will have beneficial effects for those with severe COVID-19. However, the highly contagious nature of the disease, coupled with the lack of effective treatment and global shortages in the supply of personal protective equipment (PPE), present substantial and unique challenges to physical and occupational therapists charged with the care of patients with COVID-19. The purpose of this case report is to describe the acute rehabilitation of an individual with severe COVID-19 complicated by myocarditis, focusing on both facility-wide and patient-specific strategies employed in addressing this difficult challenge.

[H1] CASE DESCRIPTION

A 50-year-old male presented to the emergency department of a large tertiary hospital with progressive dyspnea (respiratory rate (RR) = 20), hypoxemia (oxygen saturation (SpO_2) = 91% on

room air), and bilateral lung infiltrates on chest radiographs. Prior to admission, he was independent with mobility and activities of daily living (ADLs), worked as a licensed practical nurse, and lived with his wife and children. His past medical history included hypertension, managed with Lisinopril, and Type II diabetes, managed with metformin and glipizide (Charleston Comorbidity Index = 2). He tested positive for COVID-19 (via RT-PCR), and was placed on contact+droplet precautions. He was treated with supplemental oxygen (two liters via nasal cannula), ceftriaxone and doxycycline for confirmed community-acquired pneumonia, and hydroxychloroquine for COVID-19 (provided via emergency use authorization). He developed hypoxic respiratory failure (RR = 27, $Sp0_2$ = 93% on High Flow Nasal Cannula at 20 liters per minute), was intubated (FiO_2 initially 100%, weaned to 40% by end of day, PEEP = 7.5), and transferred to the Medical Intensive Care Unit (ICU) on hospital day (HD) three. There, he showed non-specific ST-segment changes on electrocardiogram, elevated NT-proBNP (peak=4529pg/ml; normal<450pg/ml), and troponin leak (peak=0.067ng/ml; normal<0.03ng/ml). Bedside echocardiography revealed moderate to severe depression of left ventricular ejection fraction (LVEF). This was believed to be new onset heart failure (HF), as nothing in the patient's history suggested impaired cardiac function prior to admission.

Despite a strong culture of early mobility at this institution, including standing PT/OT consult orders and regular participation in ICU rounds, consults for patients with COVID-19 were initially delayed as the facility focused on preventing the spread of the disease by minimizing contact with COVID+ patients. The Therapy Department responded by consulting published guidelines[9] and infection control experts as they developed a COVID-19 Service Delivery Plan to maximize the effectiveness and efficiency of care for COVID+ patients while minimizing staff

exposure to the virus (see supplemental material for details). First, a COVID+ therapy team was formed to minimize staff movement between COVID+ and non-COVID wards and reduce PPE use. Second, procedures to enhance interdisciplinary communication and coordination were established, including guidelines for appropriate rehabilitation referrals and the identification of clinical leads for the COVID+ team to coordinate care and communication. Third, a contact-free screening tool and specific guidelines for patient prioritization and management were developed to help therapists provide effective care while containing the virus.

[H2] Initial Examination

Following the implementation of the Service Delivery Plan, rehabilitation consults for this patient were generated on HD 18. Screening consisted of direct communication with nursing regarding the patient's level of arousal and trends in hemodynamic, oxygenation, and mobility status (see supplemental materials 3.1-3.3 for details). The screen indicated that the patient was appropriate for Physical therapy and occupational therapy, but would require substantial assistance. As a result, the therapists decided to co-treat the patient in this and subsequent sessions, as was suggested in the direct care guidance portion of the Service Delivery Plan. Due to the patient's COVID+ status, the therapists donned gowns, gloves, surgical masks, and face shields prior to entering the patient's room. The patient had been extubated on the previous day, and was using four liters of oxygen via nasal cannula. He presented supine in bed with telemetry, right intrajugular central venous catheter, rectal tube, Foley catheter, and a nasogastric tube. His resting hemodynamic and respiratory status (blood pressure (BP) = 120/76; heart rate (HR) = 90; RR = 13; $Sp0_2$ = 98%) was considered stable, per published guidelines for early mobility in critically ill individuals.[11] He was awake but drowsy (RASS -1),

and demonstrated significant cognitive deficits; he was oriented only to person, with poor sustained attention, delayed motor processing, and tangential thought process. He was profoundly weak (grossly <3/5 throughout) and his endurance was poor, as evidenced by fatigue, increased heart (HR = 110) and respiratory rate (RR = 26) and intermittent falls in oxygen saturation (Sp02 = 92%) with minimal activity (ie, bed mobility, sit to stand). See the Table for additional details about the patient's mobility status and rehabilitation course.

[H2] Clinical Impression 1

Severe COVID-19 is novel, but the deficits observed in this patient were consistent with those identified in studies of critical illness due to other causes.[13] Given the evidence supporting the beneficial effects of ICU-based rehabilitation on cognitive and physical function in these populations,[11-13] continued physical therapy and occupational therapy services were indicated to improve strength, balance, functional mobility, self-care, and cognition. While patients in the ICU at this institution commonly receive therapy 5 days per week, the prescribed frequency of physical therapy and occupational therapy for this patient was 2-4 times per week. This was in accordance with the prioritization guidelines in the COVID-19 Service Delivery Plan (see supplemental materials 3.5, 3.6 for details), which was developed in response to unprecedented constraints imposed by the pandemic, including the global shortage of PPE. Other aspects of the plan of care were consistent with those provided in studies of ICU-based rehabilitation,[11,13] and focused primarily on progressive mobilization, cognitive remediation, and engagement in self-care tasks (see Table for details). Inpatient rehabilitation was recommended upon discharge, due to the severity of the patient's functional limitations.

[H2] Change in Medical Status

Despite successful extubation, 2 days of participation in ICU-based rehabilitation, and transition to the ward, the patient's medical condition worsened on HD 20. He was returned to the ICU and reintubated for aspiration pneumonia and flash pulmonary edema. Echocardiography revealed biventricular systolic dysfunction (LVEF = 15%) and right ventricular dilation. He was diagnosed with COVID-19 myocarditis, and the medical team speculated that the exacerbation was brought about by cytokine storm. He was diuresed and treated with antibiotics (linezolid). He self-extubated on HD 24 and was weaned to room air, but demonstrated persistent tachycardia. On the evening of HD 25, he complained of chest pain. His electrocardiogram was stable, but reduced central venous oxygen saturation suggested the onset of decompensated HF. He was treated with aggressive afterload reduction (nitroprusside) and an intravenous inotrope (milrinone) was initiated on HD 27, gradually weaned, and discontinued on HD 43.

[H2] Clinical Impression 2

In daily consultation with the medical team during rounds, physical therapy and occupational therapy collaboratively deferred treatment at times during this period of decompensation, and proceeded cautiously when his medical stability allowed. Improvements in his medical status, cognition, and strength coincided with the initiation of inotropic support, leading to improved mobility and function (see Table for details). He was highly motived to return to his prior level of function, but his endurance and balance continued to be significantly impaired. His COVID+ status precluded his acceptance into an inpatient post-acute care rehabilitation facility. This,

along with his steady progress in rehabilitation, led to a change in discharge recommendation to home with home physical therapy and occupational therapy services.

[H2] Intervention

To prepare for discharge to home, a "rehab in place" protocol was implemented, featuring 30-minute treatment sessions five times per week to improve physical function, mobility, and endurance, and incorporating a battery of standardized outcome measures (see Table for details). However, the patient experienced persistent sinus tachycardia (resting HR = 110-120), as well as impulsivity and limited insight into his impairments. His perception of exertion was often unreliable, leading him to push himself past the point of fatigue and into heart rate ranges (HR = 160) that could be dangerous given his poor left ventricular function. This was particularly an issue during inotrope weaning, since his cardiac dysfunction caused greater physiologic stress at lower levels of activity. Due to our limited understanding of the impact of this emerging disease on the physiological response to activity, caution was warranted. Treatment sessions focused on moderate intensity functional activities (eg, transfers, standing balance, ambulation) with frequent rest breaks and careful monitoring of the patient's vital signs (upper HR range ≈ 140), breathing (pacing with activity, avoiding labored breathing), and indicators of fatigue (eg, declining movement quality). As his cognition improved, the patient was trained to use a simplified rating scale of perceived exertion ("easy", "moderate", "hard") during activity. This was coupled with education on activity pacing and energy conservation to help preserve his energy level in preparation for discharge to home.

As ambulation progressed, it was augmented with standing exercises and dynamic activities to improve strength and balance (see Table for details). He was able to ambulate to the bathroom and engage in standing ADL's (ie, grooming, bathing, and toileting) with minimal assistance. Cognitive remediation continued to focus on improving re-orientation and insight via patient recall on functional and medical progress, structured engagement in ADL's, and increased socialization via telephonic and online communication with supportive family.

[H1] OUTCOMES

The patient was weaned off milrinone on HD 43. By HD 48, he exhibited clinically important improvements on several standardized outcome measures of cognition (SLUMS[14] improved 4 points to 25) and mobility (5xSTS[15] improved 30.9 s; TUG[16] improved 4.2 s; AMPAC[17] improved 100%; see Table and Figure). He had achieved a modified independent level for ADLs, and he was ambulating 100 feet with supervision and no assistive device. He continued to exhibit balance deficits with more challenging tasks (tandem walking, eyes closed, and backwards walking). He was discharged home with his family, cardiology-recommended LifeVest and a referral for home physical therapy and occupational therapy for continued rehabilitation in his home environment. As of publication patient has been readmitted twice for HF exacerbation, requiring a three-day and a six-day hospitalization, respectively, despite bi-weekly nursing visits and telehealth follow-up. Each admission was manifested by volume overload and required optimization of his HF medications.

[H1] DISCUSSION

This case report describes the facility-wide and patient-specific strategies employed in the successful hospital-based rehab management of an individual with severe COVID-19 complicated by myocarditis. The Service Delivery Plan, implemented with the encouragement and support of the critical care team, facilitated the delivery of care while preserving PPE and containing the spread of the virus.

As this case illustrates, severe COVID-19 can deleteriously impact the movement system. Acute cardiac injury is a common complication[6] of COVID-19 and a significant cause of mortality.[18] While further research is needed to define the ideal rehabilitation approach to COVID-19, the management of this patient is broadly consistent with recent recommendations,[8] and was guided by the existing literature on rehabilitation in critical illness.[11,13] However, the constraints imposed by the pandemic contributed to a delayed start and reduced initial frequency of rehabilitation, and exacerbated the disorienting isolation of critical illness.[19] While both of these factors may contribute to poor outcomes in the critically ill,[12] our patient demonstrated substantial improvements in cognition, mobility, and function, and was able to return home with family support and home PT/OT. This successful outcome is qualified, however, by the two subsequent readmissions for HF exacerbation despite regular follow-up, which highlight the persistent health impacts of severe COVID-19.

Author Contributions

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Disclosure

The authors' institutional review board waives ethics approval for case reports. The patient gave written consent for publication of this case report.

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TABLE: Rehabilitation Course[a]

#	HD	Mobility/Activity	Cognition and Function	Outcome Measures
1	18	Supine to sit with max A of 2 Mod A for sitting EOB	Following 50% of commands, max A for ADLs	
2	19	Supine to sit, sit to stand with max A of 2	Attention span <2 minutes, max multimodal cues needed	
3	24	Supine to sit EOB with max A of 2 Max A for sitting EOB	Following 75% of commands	
4	25	Sit to stand, pivot to char with mod A of 2	Alert & Oriented to self 100% of session	
5	26	Supine to/from sit mod A of 2 Sitting EOB with supervision Sit to stand, pivot to char with mod A of 2, static standing with mod A of 2	Confused, perseverative, tangential requiring moderate cueing for safety	
6	27	Supine to sit, sit EOB with SBA of 1 Deep breathing/sitting balance (5 min), Sit to stand with mod A of 1, SBA of 1, Standing balance/reaching (3 min)	Min A for grooming tasks in supported sitting	
7	30	Sit to stand min A Ambulation 3 feet, min/HHA of 1, SBA of 1	Following 100% of commands	
8	31	Sit to stand min A Ambulation 5 feet backwards and forwards min/HHA of 1, x3 with seated rest breaks and breathing control Seated knee ext, ankle pumps 1x10	Alert, Oriented x4, min multimodal cues needed for attention to tasks, mod A for upper & lower body dressing, independent with feeding	
9	32	Ambulation 5 feet backwards and forwards with min/HHA x1, then rest, then once again, Standing marching x 15 sec Sit to/from x 5 with supervision		5xSTS = 38 s SLUMS = 21
10	35	Sit to/from stand with supervision x5		5xSTS = 22 s
11	37	12 feet x 2, paced breathing, standing unilateral hip abduction 2x10 with min/HHA	Supervision for grooming tasks in standing in bathroom	5xSTS = 14 s
12	39	12 feet x 2, standing unilateral hip abduction and extension 2x10 min/HHA		TUG = 14 s
13	40	15-20 feet x 3, standing unilateral hip abduction and extension 2x10 with supervision, activity pacing education		TUG = 10.4 s
14	41	15 feet x 5 with supervision managing IV pole, paced breathing, energy conservation education	Upper & Lower body bathing in standing with supervision	5xSTS = 8.6 s
15	43	15 feet x3 with supervision managing IV pole, marching with UE cross with supervision 2x15, energy conservation	simulated home management tasks in standing with supervision	
16	44	20 feet x 5 with supervision Standing marching with UE cross 2x20	Dynamic UE exercise in standing with supervision	TUG = 10 s
	TRANSFER TO WARD			
17	45	6 min continuous at “moderate” exertion		TUG = 9.8 s 5xSTS = 7.1 s

				SLUMS = 25
18	47	>100 feet with supervision, tandem and backward walking		FGA = 21/30
19	48	>100 feet independently	Modified independent for ADLs	

[a]Summary of 19 rehabilitation sessions over the patient's 48-day hospital stay. The patient was in the intensive care unit for visits 1-16, and on the ward for the remaining sessions.
Note the magnitude of change in the outcome measures; SLUMS Δ = 4; TUG Δ = 4.2 s; 5XSTS Δ = 30.9 s. No assistive device was used during performance of the 5xSTS, TUG, or FGA. # = PT session number; 5X STS = Five Time Sit to Stand; A = assistance; ADLs = activities of daily living; EOB = edge of bed; FGA = Functional Gait Assessment; HD = Hospital day; HHA = hand-held assistance; SBA = stand-by assistance; SLUMS = Saint Louis University Mental Status Exam; TUG = Timed "Up and Go"; UE = upper extremity.

FIGURE: Activity measure for post-acute care (AM-PAC) disability scores. AM-PAC activity (solid line) and mobility (dotted line) scores, expressed as percent disability,[17] for each rehabilitation session.