Interdisciplinary Management for the First Patient With Post–COVID Double-Lung Transplantation in Inpatient Rehabilitation in the United States: A Case Report

RUNNING HEAD: Post-COVID Lung Transplantation Rehabilitation

TOC CATEGORY: COVID-19

ARTICLE TYPE: Case Report

SUBMITTED DATE: September 16, 2021

REVISED DATE: March 11, 2022

ACCEPTED DATE: May, 1, 2022

AUTHOR BYLINE: Tessa Herrmann, PT, DPT[1]*; Jacqueline Iglesias, PT, DPT[1]; Samantha Smith MS, OTR/L[1]

AUTHOR INFORMATION:

[1] Shirley Ryan AbilityLab (formerly Rehabilitation Institute of Chicago)

355 E Erie, Chicago, IL 60611

© The Author(s) 2022. Published by Oxford University Press on behalf of the American Physical Therapy Association. All rights reserved. For permissions, please email: journals.permissions@oup.com

UNCORRECTED MANUSCRIPT

Corresponding Author*

Tessa Herrmann, Physical Therapist

Email: TessaLH@gmail.com

KEYWORDS: Case Report; COVID-19; Inpatient Rehabilitation; Lung Transplant; Physical Therapy; Occupational Therapy; Self-Care.

[H1]Abstract

Objective. In the setting of the COVID-19 pandemic, lung transplantation is being used as a life-saving treatment. This case report describes the rehabilitation course of the first documented individual in the United States post–bilateral lung transplant for COVID-19.

Methods. Case Description: the patient is a 28 year old woman who was previously healthy and who failed all other life-saving medical interventions before undergoing bilateral lung transplantation, resulting in an extended hospital stay and significant physical debility.

Results. Through an interdisciplinary rehabilitation approach, the patient was able to achieve functional improvements in strength, balance, endurance, and functional mobility to safely discharge home.

Conclusion. Research is needed regarding optimal treatment of this patient population, as lung transplantation continues to be used for long-term medical management of COVID-19 infection.

Impact. This is a case report describing rehabilitation for the first documented individual in the United States post–bilateral lung transplant for COVID-19.

UNCORRECTED MANUSCRIPT

[H1] Introduction

The COVID-19 pandemic has resulted in a number of individuals requiring rehabilitation after prolonged hospitalization. This population presents unique challenges to the acute inpatient phase of rehabilitation due to significant and ongoing functional impairments. After an intensive care unit (ICU) stay, most patients suffer from impaired lung function, critical illness polyneuropathy and/or myopathy and deconditioning.[1] Evidence is rapidly evolving for the rehabilitation of these individuals, although no published guidelines exist for best rehabilitation practice.

Bilateral lung transplantation has emerged as a life-saving treatment for individuals with severe COVID-19.[2] Some patients with severe COVID-19 develop irreversible lung damage and cannot be weaned off mechanical ventilation. Lung transplantation becomes the only curative option for restoring lung function.[2] The use of bilateral lung transplantation after severe COVID-19 infection presents new and unique challenges for rehabilitation professionals. These patients may have had a relatively short course of illness and inactivity compared to individuals with chronic pulmonary conditions that go on to receive lung transplantation.[3]

Prior to the COVID-19 pandemic, lung transplants were typically used to address prolonged chronic illness, which resulted in debility and deconditioning leading up to the time of transplantation.[4] Patients requiring lung transplantation often experience reduced exercise capacity, muscle weakness, impaired mobility and independence.[5] Limited guidelines exist for inpatient rehabilitation of individuals after lung transplant. A recently published systematic review[6] found that exercise training appears to be beneficial before and after lung transplantation. However, the type of exercise training varied across inpatient and outpatient

UNCORRECTED MANUSCRIPT

settings and was limited by the lack of controlled trials. Further research is needed on the effects of exercise training on post-transplant clinical outcomes in inpatient rehabilitation.

Concurrently, there is no published evidence[7] for the rehabilitation of individuals post lung transplant following a severe COVID-19 infection. Here, we present a unique case study of the interdisciplinary inpatient rehabilitation course of the first patient in the United States to receive a bilateral lung transplant due to severe acute respiratory failure from COVID-19.

[H1] Case Description

A 28 year old previously independent-woman with a past medical history of Neuromyelitis Optica on immunosuppression was initially admitted to acute care on April 26, 2020, and sustained a prolonged hospitalization (66 days) for acute hypoxemic respiratory failure due to COVID-19 pneumonia. The acute care clinical course required extended mechanical ventilation and extracorporeal membrane oxygenation (ECMO). Lung compliance, gas exchange, and chest imaging showed worsening or no improvement over several weeks in the ICU. Given the patient's sedation and decreased mental status, her medical power of attorney consented for bilateral lung transplant for management of complications related to COVID-19, the first to be performed in the United States. After transplantation, she was removed from mechanical ventilation, her tracheostomy was decannulated, and her oxygen needs were weaned to room air.[2]

This patient presented to a free-standing inpatient rehabilitation facility (IRF) 26 days after lung transplant and 66 days after initial hospitalization for COVID-19. Upon admission she tested negative for COVID-19 via PCR swab and did not require special isolation. She presented with significant deficits in strength and endurance, resulting in decreased independence in activities of daily living (ADLs) and functional mobility (Tab. 1 and Tab. 2). She was evaluated and treated

UNCORRECTED MANUSCRIPT

by a comprehensive rehabilitation team throughout her stay. Therapies consisted of a combined 3 hours of therapy per day, 5 to 7 days per week. Therapies included physical therapy, occupational therapy, and speech language pathology. The scheduled 3 hours of therapy occurred between the hours of 07:30-17:00 with a break for lunch daily from 12:00-13:00 and intermittent rest breaks between sessions allowing for recovery. Respiratory treatments and psychology sessions occurred outside of physical therapy, occupational therapy, and speech-language pathology sessions.

Progression of interventions was limited by a 5 day readmission to acute care early in her rehabilitation course due to worsening chest pain and new leukocytosis. Imaging performed at that hospital revealed a pericardial effusion. Chest radiography, chest CT, and electrocardiography showed no acute changes; thus, her medical and transplant team determined her to be hemodynamically and clinically stable for return to IRF.

Throughout her rehabilitation course, the patient was followed closely by a medical team at the IRF, who coordinated with her transplant team for optimized medical management. Medications at discharge are listed in Table 3.

[H1]Therapy Evaluations

[H2]Physical Therapy

On initial physical therapist evaluation, the patient demonstrated significant strength deficits in bilateral lower extremities (manual muscle testing revealing grades of grossly 3 out of 5 in major muscle groups), deconditioning, and need for physical assistance with bed mobility, transfers, and limited ambulation distance. Of note, ambulation distances were limited to a maximum of 25 feet due to fatigue, deconditioning, and anxiety. The patient required significant rest breaks and

UNCORRECTED MANUSCRIPT

cueing for deep breathing to resolve anxiety. Initial standardized outcome measures demonstrated significant endurance deficits below age-related norms on the 6-Minute walk test (6MWT) and Berg Balance Scale (BBS), revealing high risk for falls[8,9] (Tab. 1). Overall, initial impressions were that the patient presented with significant deficits in functional mobility, functional strength, and deconditioning. Functional goals for the patient's stay were set at the independent to supervision level to facilitate safe discharge home into the community.

[H2]Occupational Therapy

On initial occupational therapist evaluation, the patient exhibited decreased activity tolerance, strength, range of motion, and coordination in bilateral upper extremities required to complete activities of daily living (ADLs). Frequent rest breaks and physical assistance were required during bathing and dressing due to dyspnea. Canadian Occupational Performance Measure (COPM) was used to track perceived improvements in performance and satisfaction scores with self-identified meaningful goal areas.[10] The COPM does not have sufficient evidence validating use with the lung transplant population, but strong patient-reported outcomes were achieved by time of discharge (Tab. 1 and Tab. 2).

Further occupational therapist clinical observations and functional assessment included vision screening due to her history of Neuromyelitis Optica without significant changes reported. The patient endorsed decreased light touch sensation in both hands and feet. She exhibited tremors in both hands, with challenges observed in opening containers, writing, and typing. The Menu Task screening tool indicated intact functional cognition, though made errors related to multitasking and attention to detail. The Assessment of Motor and Process Skills (AMPS) was performed to assess occupational performance with subtasks that involved making a sandwich and folding a basket of laundry. The AMPS findings indicated an increase in effort and disorganization during

UNCORRECTED MANUSCRIPT

tasks. Her most notable breakdown was in her ability to obtain/hold objects and move herself and objects (ie, needing two hands to carry heavy items, decreased fluidity of upper extremity movement, and grip slips).

[H1]Treatment

[H2]Physical Therapy

Physical therapist interventions focused on increasing strength and endurance to improve functional mobility in a variety of methods, including interval and treadmill training. Interventions also included diaphragmatic retraining and respiratory muscle strengthening[11] to improve lung volumes and decrease subjective report of dyspnea. Respiratory muscle strength training was initiated early in her stay given the patient's healed tracheostomy site at admission. All activities were performed while monitoring heart rate and oxygen saturation (SpO2) using a peripheral forehead monitor. Parameters for goal vital response to activity were defined as SpO2 greater than 92%, heart rate goal for moderate intensity (50% to 70% of age-related heart rate max), and the Borg Dyspnea Scale to monitor shortness of breath/exertion with a goal of less than or equal to 4 out of 10 or not more than "somewhat severe" shortness of breath.[12]

[H2]Occupational Therapy

Occupational therapist interventions heavily focused on an occupation-based approach for basic ADL and instrumental activities of daily living (IADL) retraining. ADLs consisted of dressing, bathing, toilet, and shower transfers, integrating adaptive equipment for energy conservation, and monitoring ratings of perceived exertion throughout. Complex IADL tasks included laundry, meal preparation, simulated grocery shopping, functional mobility for reaching and transporting items, and computer typing with the goal of returning to work at home. To support successful

UNCORRECTED MANUSCRIPT

performance of valued occupations, the Occupational Therapy Practice Framework was referenced and supported integration of diaphragmatic breathing, relaxation strategies, and identifying hobbies/occupations (reading, television shows, phone/computer use, and exercise programs) to aid with anxiety.[13] American Occupational Therapy Association guidelines for COVID population were applied, though guidelines did not specifically address the post-COVID double-lung transplant population.[14] This patient was referred to recreational therapy for leisure activities and to the occupational therapy technology center to increase independence with phone and computer use.

[H2]Speech Language Pathology

This patient was seen by SLP for 3 visits, including evaluation, in order to prioritize physical and occupational therapy. SLP observed mild dysphonia, reduced breath support, and mild dysphagia, as noted by reduced bolus propulsion. SLP targeted respiratory muscle strengthening via expiratory muscle strength training program that she then performed independently. At time of discharge, the patient had no dietary restrictions. Ongoing SLP was recommended for voice and higher-level cognition at the next level of care.

[H2]Other Considerations

Anxiety was often expressed throughout therapy sessions and interfered with sleep quality. This anxiety was related to fear of reinfection being around other patients in treatment areas, as well as general anxiety and post-traumatic stress disorder (PTSD) surrounding her traumatic hospitalization and ongoing nightmares.

Psychology and psychiatry followed this patient closely throughout her stay and provided support. Notes documented nightmares relating to drowning and vivid memories of disturbing

UNCORRECTED MANUSCRIPT

events that she did not believe actually happened. She also experienced anxiety attributed to dependence on others and the need for assistance with functional activities. She was started on an antidepressant and given an option to use as-needed anxiety medications, which she did not request during her stay. Distraction techniques and diaphragmatic breathing were helpful calming strategies to delay the onset of panic attacks. The patient was aided by strong support from her mother, boyfriend, friends, and family. Neuropsychological testing was recommended after discharge to determine readiness for returning to work.

Due to her fear of re-infection from others, her therapy was scheduled at the beginning and/or the end of the treatment day to allow for limited interaction with other patients. Differences in performance and anxiety were noted when she was around other patients but improved throughout her stay.

[H2]Outcomes

At the end of her length of stay, the patient showed significant improvements in all outcome measures and functional levels meeting all therapy goals, as noted in Table 1 and Table 2. She reported a decrease in dyspnea and anxiety across all areas of functional mobility. The patient was able to discharge home with family at an independent level for most mobility and ADLs. This included ambulating community distances without assistive device use. She required supervision for stairs, shower transfers, bathing, and IADLs due to safety concerns with continued fatigue and decreased balance. These deficits were noted by 6MWT significantly below age-related norm and BBS placing the patient in the 50% fall risk category even at discharge (Tab. 1 and Tab. 2).[8,9] The patient returned home with home health therapies before recommended transition to outpatient rehabilitation to address high-level balance, endurance, return-to-work, and increasing independence with community re-integration skills.

UNCORRECTED MANUSCRIPT

[H1]Discussion

A case of inpatient rehabilitation after bilateral lung transplantation for COVID-19 is presented in this report. To date, another case study has been published by Rossi et al of Italy.[15] Both cases highlight common themes of psychological involvement and the importance of multidisciplinary collaboration. Given that Italy provides universal health care, medical care and therapy practices may not be identical between systems. This case occurred in a free-standing rehabilitation hospital, while the case described by Rossi et al occurred in a hospital ward. Currently, limited evidence exists for specific guidelines for the rehabilitation of patients after lung transplant and there are no published therapy recommendations for the post-COVID lung transplant population. Interventions of moderate-intensity cardiovascular training, respiratory muscle strength training, functional mobility retraining, ADL and IADL retraining, and relaxation strategies were implemented to address the patient's primary goal of returning home from the hospital. This patient was successfully able to regain the skills needed to safely discharge home and complete everyday activities with family support. More literature is indicated for assessments and interventions for the interdisciplinary team of physical therapy, occupational therapy, and speech-language pathology) in this patient population.

Previous studies on lung transplant rehabilitation have demonstrated that exercise is beneficial after transplantation. However, exercise is defined in broad terms without specific guidelines. Future research would be beneficial to examine moderate versus high intensity exercise, dosing of respiratory muscle strength training, and any lingering long-term symptoms related to COVID-19 infection despite no evidence of the virus.[2]

Since this case, additional patients who received bilateral lung transplant for management of COVID-19 have presented to this facility for inpatient rehabilitation. In these cases, therapists

UNCORRECTED MANUSCRIPT

have seen similar, often more profound deficits in strength and function depending on multiple factors. These factors may include time prior to lung transplantation, ongoing needs for ECMO or mechanical ventilation, additional organ involvement, diet/nutrition status, and age. Emerging evidence indicates that survivors of severe COVID-19 infection can experience prolonged neuromuscular symptoms including peripheral nerve injury and diaphragm dysfunction.[16,17] These may contribute to ongoing functional impairments that differ from the rehabilitation course of other lung transplant recipients with non-COVID lung disease.

[H1]Conclusion

In summary, after engaging in 21 days of inpatient rehabilitation after bilateral lung transplant for COVID-19, this patient was discharged home at an independent/supervision level with ongoing home health physical therapy and occupational therapy. This case demonstrates that in the inpatient rehabilitation setting, a multidisciplinary team approach with a focus on moderate-intensity activity and functional retraining can be safely implemented to meet a patient's goal of returning home. While she made meaningful improvements in her outcome measures (Tab. 1 and Tab. 2) her scores continued to be below age-related norms signifying continued physical disability at discharge. As patients continue to recover and experience long-term effects from COVID-19 and prolonged ICU stays, the potential for PTSD and ongoing anxiety should be considered during assessment and treatment. Since the body of evidence is limited for recipients of both bilateral lung transplants and bilateral lung transplants in patients post COVID-19 infection, further research is needed to optimize rehabilitation outcomes for this emerging patient population. As this is a single case, the major limitation is that it is not generalizable to an entire patient population.

UNCORRECTED MANUSCRIPT

Author Contributions

Concept/idea/research design: T. Herrmann, J. Iglesias, S Smith

Writing: T. Herrmann, J. Iglesias, S. Smith

Data collection: T. Herrmann, J. Iglesias, S. Smith

Data analysis: T. Herrmann, J. Iglesias, S.Smith

Project management: T. Herrmann

Providing participants: J. Iglesias, S. Smith

All authors contributed to the analysis of intervention and results as well as to the writing of the manuscript.

Acknowledgments

The authors acknowledge Miriam Rafferty, PT, DPT, PhD, board-certified clinical specialist in neurologic physical therapy, Research Scientist II, Shirley Ryan AbilityLab, and Assistant Professor, Department of Physical Medicine & Rehabilitation, Northwestern University, for her mentoring and guidance during the writing process.

Ethics Approval

The participant provided written informed consent to participate in a case report using an organization-approved process. This case report meets HIPAA requirements for disclosure of protected health information.

Funding

UNCORRECTED MANUSCRIPT

No funding or grants were provided for this study; all authors receive a salary from Shirley Ryan AbilityLab. The equipment used for this study was provided by Shirley Ryan AbilityLab as part of standard practice.

Disclosures

The authors completed the ICMJE Form for Disclosure of Potential Conflicts of Interest and reported no conflicts of interest.

UNCORRECTED MANUSCRIPT

Tables

Table 1. Outcome Measurements[a]

Outcome Measures	Initial Scores (Days 1–3)	Interim (Day 12)	Discharge (Days 18–20)
Physical Therapy Outcome Measures			
6MWT (ft) (norm for woman, 29 y, with same demographics = 2368 ft)	92 ft	656 ft	1090 ft
10MWT (m/s) (norm for woman, 29 y = 1.34 m/s)[18]			.86 m/s; .99 m/s
BBS (out of 56)[9]	26	40	48
MIP (cm H_2O)	18 cm H_20		41 cm H_20
MEP (cm H_20)	75 cm H_20		
Physical Therapy Quality Indicators[b]			
Transfers	Partial assist	Supervision	Independent
Ambulation 10 ft	Partial assist	Supervision	Independent
Ambulation 50 ft	Not safe to perform	Supervision	Independent
Ambulation 150 ft	Not safe to perform	Supervision	Independent
Stairs, 1 step	Not safe to perform	Supervision	Supervision
Stairs, 4 steps	Not safe to perform	Supervision	Supervision
Occupational Therapy Outcome Measures			
Bilateral grip strength[19] (age/gender norms: LUE = 63.5 lb, RUE = 74.5 lb)	LUE = 16 lb RUE = 19.7 lb	--	LUE = 24 lb RUE = 25.3 lb

UNCORRECTED MANUSCRIPT

Bilateral key pinch strength (age/gender norms: LUE = 16.6 lb, RUE = 17.7 lb)	LUE = 3.1 lb RUE = 3.7 lb	--	LUE = 5.2 lbs RUE = 6.5 lbs
BTA[c]	15/20 (112 s)	--	19/20 (78 s)
The Menu Task (cognitive screening tool)	--	Scored 8/12	--
Occupational Therapy Quality Indicators[b]			
Eating	Setup	Setup	Indep
Grooming	Setup	Setup	Indep
Bathing	Partial/Mod A	Sup/Touch A	Sup/Touch A
Toileting	Substantial/Max A	Sup/Touch A	Indep
Upper extremity dressing	Sup/Touch A	Setup	Indep
Lower extremity dressing	Partial/Mod A	Sup/Touch A	Indep
Footwear management	Substantial/Max A	Sup/Touch A	Indep
Toilet transfer	Partial/Mod A	Sup/Touch A	Indep
Shower transfer	Not safe to perform	Sup/Touch A	Sup/Touch A

[a] 6MWT = 6-Minute walk test; 10MWT = 10-Minute walk test; BBS = Berg Balance Scale; BTA = The Bilateral Task Assessment; Indep = independent patient completes the activity by him/herself with no assistance from a helper; LUE = left upper extremity; MEP = maximal expiratory pressure; MIP =

UNCORRECTED MANUSCRIPT

maximum inspiratory pressure; Partial/Moderate Assistance = helper does less than half the effort; RUE = right upper extremity; Substantial/Maximal Assistance = helper does more than half the effort; Supervision/Touch A = helper provides verbal cues and/or touching/steadying and/or contact guard assistance as patient completes activity; assistance may be provided throughout the activity or intermittently.

[b] Quality Indicators are standardized, evidence-based measures of health care quality used to track clinical performance and outcomes. Definitions are provided from CMS IRF-PAI version 3.0 Centers for Medicare & Medicaid Services. IRF-PAI and IRF QRP Manual. ttps://www.cms.gov/files/document/final-irf-pai-version-40-effective-october-1-2020.pdf-0.

[c] The BTA was developed at the Shirley Ryan AbilityLab to functionally assess a person's ability to integrate both upper extremities in a standardized and clinically relevant series of tasks. There are limited outcome assessments that measure the performance of bilateral upper extremities (BUE) in functional tasks involving various hand functions that are quick to perform. The BTA subcomponents include: managing buttons, opening jars, cutting putty with knife/fork, folding paper and put into envelope, and putting four paperclips onto envelope. The maximum score for the BTA is 20, implying little to no dysfunction for BUE integration; the minimum score, 0, implies significant dysfunction when performing BUE tasks.

UNCORRECTED MANUSCRIPT

Table 2. Goal Achievement as Measured by the Canadian Occupational Performance Measure (COPM) (Range = 1–10)

COPM Goals	Initial Performance	Initial Satisfaction	Discharge Performance	Discharge Satisfaction
1. Stand by myself	3/10	3/10	9/10	9/10
2. Use the bathroom myself	5/10	1/10	9/10	9/10
3. Upper body dressing	8/10	8/10	9/10	9/10
4. Lower body dressing	4/10	5/10	8/10	7/10
5. To be able to stand to reach things I need	7/10	5/10	9/10	9/10

UNCORRECTED MANUSCRIPT

Table 3. Medication Regimen[a]

Medication	Dosage	Frequency
Acetaminophen	650 mg	Every 6 h as needed for mild pain (pain scale = 1–3)
Azithromycin	250 mg	Every Monday, Wednesday, Friday
Clonazepam	0.25 mg tablet, dissolved under tongue	2 times per d
Docusate-senna	50 mg–8.6 mg oral tablet	2 times per d as needed for constipation
Lidocaine 4% topical film	2 patches, placed on skin	On for 12 h, off for 12 h
Loperamide	2 mg	Every 6 h as needed for diarrhea
Magnesium oxide	800 mg	2 times per d
Mycophenolate mofetil	500 mg	4 times per d
Nystatin	100,000 units/g topical powder, 1 application, placed on skin	2 times per d
Ondansetron	4 mg	Every 4 h as needed for nausea
Pantoprazole	40 mg	Once a d (morning)
Penicillin V potassium	500 mg	Every 12 h
Posaconazole	300 mg	Once a d (in morning)
Prednisone	30 mg	Every d
Pregabalin	25 mg,	Every d
Psyllium	3.4 g/5.8g powder	Every d for reconstitution
Sertraline	50 mg	Once per d
Sulfamethoxazole-trimethoprim	800mg–160 mg oral tablet	Every Monday, Wednesday, Friday
Tacrolimus	2 mg	2 times per d
Tramadol	50 mg	Every 6 h as needed for moderate pain (pain scale = 4–6)
Valganciclovir	900 mg	Every d

[a] Taken by mouth unless otherwise specified.

UNCORRECTED MANUSCRIPT

[H1]References

1. Zhao HM, Xie YX, Wang C. Recommendations for respiratory rehabilitation in adults with COVID-19. Chin Med J (Engl). Apr 9 2020

2. Bharat A, Querrey M, Markov NS, Kim S, Kurihara C, Garza-Castillon R, Manerikar A, Shilatifard A, Tomic R, Politanska Y, Abdala-Valencia H, Yeldandi AV, Lomasney JW, Misharin AV, Budinger GRS. Lung transplantation for patients with severe COVID-19. Sci Transl Med. 2020 Dec 16;12(574):eabe4282. doi: 10.1126/scitranslmed.abe4282. Epub 2020 Nov 30. PMID: 33257409.

3. Bharat, Ankit et al. Early outcomes after lung transplantation for severe COVID-19: a series of the first consecutive cases from four countries. The Lancet Respiratory Medicine, Volume 9, Issue 5, 487 – 497. 2021 March 31 DOI:https://doi.org/10.1016/S2213-2600(21)00077-1

4. Alvarez A, Moreno P. Demographic ageing and its influence on current lung transplant practice. *J Thorac Dis*. 2019;11(Suppl 15):S1992-S1994. doi:10.21037/jtd.2019.06.71

5. Wickerson L, Rozenberg D, Janaudis-Ferreira T, Deliva R, Lo V, Beauchamp G, Helm D, Gottesman C, Mendes P, Vieira L, Herridge M, Singer LG, Mathur S. Physical rehabilitation for lung transplant candidates and recipients: An evidence-informed clinical approach. World J Transplant. 2016 Sep 24;6(3):517-31. doi: 10.5500/wjt.v6.i3.517. PMID: 27683630; PMCID: PMC5036121.

6. Hume E, Ward L, Wilkinson M, Manifield J, Clark S, Vogiatzis I. Exercise training for lung transplant candidates and recipients: a systematic review. Eur Respir Rev. 2020 Oct 28;29(158):200053. doi: 10.1183/16000617.0053-2020. PMID: 33115788.

UNCORRECTED MANUSCRIPT

7. Hermann M, Pekacka-Egli AM, Witassek F, Baumgaertner R, Schoendorf S, Spielmanns M. Feasibility and Efficacy of Cardiopulmonary Rehabilitation After COVID-19. *Am J Phys Med Rehabil*. 2020;99(10):865-869. doi:10.1097/PHM.0000000000001549

8. Jenkins S, Cecins N, Camarri B, Williams C, Thompson P, Eastwood P. Regression equations to predict 6 minute walk distance in middle-aged and elderly adults. Physiotherapy Theory and Practice, 25(7):1-7, 2009

9. Muir SW, Berg K, Chesworth B, Speechley M. Use of the Berg Balance Scale for predicting multiple falls in community-dwelling elderly people: a prospective study. Phys Ther. 2008;88:449-459.

10. Sewell, L., & Singh, S. J. (2001). The Canadian Occupational Performance Measure: Is it a Reliable Measure in Clients with Chronic Obstructive Pulmonary Disease? *British Journal of Occupational Therapy*, *64*(6), 305–310. https://doi.org/10.1177/030802260106400607

11. Abodonya, Ahmed M. MD; Abdelbasset, Walid Kamal PhD; Awad, Elsayed A. MD; Elalfy, Ibrahim E. MDe; Salem, Hosni A. MD; Elsayed, Shereen H. PhD Inspiratory muscle training for recovered COVID-19 patients after weaning from mechanical ventilation, Medicine: April 02, 2021 - Volume 100 - Issue 13 - p e25339

12. Borg, G. (1998). *Borg's perceived exertion and pain scales.* Human Kinetics.

13. Occupational Therapy Practice Framework: Domain and Process—Fourth Edition. (2020). *American Journal of Occupational Therapy*, *74*(Supplement_2). https://doi.org/10.5014/ajot.2020.74s2001

14. *AOTA.org*, 2020, www.aota.org/Practice/Health-Wellness/COVID19/decision-guides.aspx.

UNCORRECTED MANUSCRIPT

15. Rossi, Veronica, Serena Tammaro, Martina Santambrogio, Mariangela Retucci, Francesca Gallo, Stefania Crotti, Marco Mantero, Mario Nosotti, Emilia Privitera, and Alessandro Palleschi. 2021. "Physiotherapy Approach After Lung Transplantation in a Critically Ill COVID-19 Patient: A Case Report". Monaldi Archives for Chest Disease, November. https://doi.org/10.4081/monaldi.2021.2004.

16. Andalib S, Biller J, Di Napoli M, Moghimi N, McCullough LD, Rubinos CA, O'Hana Nobleza C, Azarpazhooh MR, Catanese L, Elicer I, Jafari M, Liberati F, Camejo C, Torbey M, Divani AA. Peripheral Nervous System Manifestations Associated with COVID-19. Curr Neurol Neurosci Rep. 2021 Feb 14;21(3):9. doi: 10.1007/s11910-021-01102-5. PMID: 33586020; PMCID: PMC7882462.

17. Farr E, Wolfe AR, Deshmukh S, et al. Diaphragm dysfunction in severe COVID-19 as determined by neuromuscular ultrasound. Ann Clin Transl Neurol. 2021;8(8):1745-1749. doi:10.1002/acn3.51416

18. Bohannon, R. W., & Williams Andrews, A. (2011). Normal walking speed: a descriptive meta-analysis. Physiotherapy, 97(3), 182–189. https://doi.org/10.1016/j.physio.2010.12.004

19. Tyler, H., Adams, J., & Ellis, B. (2005). What can Handgrip Strength tell the Therapist about Hand Function? *The British Journal of Hand Therapy*, *10*(1), 4–9. https://doi.org/10.1177/175899830501000101

UNCORRECTED MANUSCRIPT