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The Role of Occupational Therapy in Patients Requiring Extracorporeal Membrane Oxygenation with Coronavirus Disease: A Pilot Case Series

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Abstract

The purpose of this study is to describe the occupational therapy (OT) course and functional outcomes in critically ill patients requiring mechanical ventilation (MV) and extracorporeal membrane oxygenation (ECMO) with coronavirus (COVID-19). This is a retrospective case series from a quaternary care hospital for patients with confirmed COVID-19 from April 2020 to July 2021. Patients were included in the study if they were admitted to the intensive care unit (ICU) on MV, on ECMO, and had OT during their hospitalization. The Activity Measure for Post-Acute Care (AM-PAC) "6-Clicks" was utilized to track each patient's functional progress throughout their hospitalization. A total of 11 (n = 11) patients that met study criteria were included in the series. A total of 5 (n = 5, 45%) patients were seen while on ECMO, whereas the remainder (n = 6, 54%) were treated post-ECMO decannulation. The ECMO group had OT initiated earlier in the hospitalization than the post-ECMO group at 13.2 days versus 23.1 days, respectively. AM-PAC scores improved in the ECMO group by 40.41% and post-ECMO group by 23.75%. Patients who received OT for COVID-19 while on ECMO made substantial gains in their functional status by discharge compared to those who received OT only after decannulation. There were no adverse events in this case series. Future research should explore the impact of OT on functional and cognitive outcomes for this critically ill and unique patient population.

Keywords: COVID-19, extracorporeal membrane oxygenation, intensive care unit, occupational therapy, rehabilitation

Introduction

Coronavirus disease 2019 (COVID-19) is a worldwide pandemic caused by acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (CDC, 2021). Symptoms can range from asymptomatic to presymptomatic infection, mild illness, moderate illness, severe illness, or critical illness (CDC, 2021). Patients can progress to more severe COVID-19 infection which may require mechanical ventilation (MV) and use of Extracorporeal Membrane Oxygenation (ECMO). Acute respiratory distress syndrome (ARDS) is prominent in approximately 14% to 23% of those with severe COVID-19 illnesses requiring ICU admission (Eggman et al., 2020; Fan et al., 2018). ARDS is associated with high morbidity (40%) especially in the COVID-19 population (Marini & Gattioni, 2020; Spadaro et al.,2020). While patients are ventilated, they may require analgesics, sedatives, or chemical paralysis to maintain compliance with the ventilator in addition to inotropes of vasopressors for hemodynamic stability (Fan et al.,2018).

If adequate oxygenation is not achieved given clinical conditions, mechanical circulatory support such as ECMO may be required (Shekar et al., 2020). ECMO is an artificial lung and heart machine which drains deoxygenated blood from a central vein and returns oxygenated blood to the patient through either a vein or artery after it pumps through a membrane oxygenator and removes carbon dioxide (Fan et al., 2018). With critical illness, there is substantial muscle wasting within the first week - up to 20% by day seven (McWilliams et al., 2020). Patients who survive ARDS are at risk for physical dysfunction, neurocognitive disorders, and worsened quality of life affecting performance of activities of daily living (ADLs) and instrumental activities of daily living (IADLs) (Spadaro et al., 2020). This necessitates the need for occupational therapy

intervention for functional recovery during critical illness (Costigan et al., 2019; Weinreich et al., 2017).

Within recent years, the role of OT in the ICU has continued to grow and demonstrates that acute care rehabilitation programs are safe, feasible, and can be associated with positive outcomes including improved functional independence at discharge, improved functional mobility distance at discharge, lower rates of ICU delirium and weakness, and decreased duration of mechanical ventilation (Weinreich et al., 2017). Literature supports the hypothesis that physical rehabilitation for patients with ARDS requiring ECMO is safe, with a multidisciplinary team including ECMO specialists or perfusionists, respiratory therapists (RT), physical therapists (PT), and ECMO nurses (RN) using procedural considerations, mobility safety checklists, and treatment guidelines (Abrams et al., 2014; Ferreira et al., 2019; von Stumm et al., 2016). Despite these advances, the role of OTs in the ICU is not currently well established in literature, while current interventions are focused on physical rehabilitation with a growing need for delirium prevention and functional ADL integration (Costigan et al., 2019).

Limited research exists solely on the role of OT in patients requiring ECMO, but several case studies and systematic reviews highlight the importance of early rehabilitation and physical therapy with this population (Abrams et al., 2014; Ferreira et al., 2019; von Stumm et al., 2016). The purpose of this manuscript is to describe the role and importance of early OT intervention for patients requiring ECMO with COVID-19 through improvement of functional outcomes using The Activity Measure for Post-Acute Care (AM-PAC™) “6-Clicks” Daily Activity screen.

Methods

This case series was performed in compliance with relevant laws and institutional guidelines. The Mayo Clinic Institutional Review Board deemed this study exempt in 2021 (IRB Application #21-010129). Written consent was not required as all outcome measures were collected as part of routine care and the need for consent was waived for retrospective chart review. Inclusion criteria included referral to OT from ICU team and ECMO cannulation (veno-venous (VV) or veno-arterial (VA)) due to COVID-19 diagnosis from April 1, 2020, to July 1, 2021, for adults at a 304-bed quaternary care hospital. Patients were deemed appropriate for ECMO cannulation by specific medical requirements set by cardiothoracic surgeons and intensivists. Referral to OT requires consultations to be placed for evaluation and treatment by the ICU team at their discretion. Patients were retrospectively included in the study once these five inclusion criteria were met. Thirteen patients met the initial inclusion criteria, however two expired during hospitalization and were excluded.

Table 1

Patient Characteristics Obtained in Chart Review

Patient Characteristics	Hospital Course	Medical Course	Occupational Therapy
Age, yr	Length of stay, d	D-dimer	Number of sessions
Sex	Number of ECMO days	Ventilator settings each therapy session	Number of sessions on ECMO
Race	Percentage of days on ECMO	ECMO settings each therapy session	Time to consult, d
		Pertinent medications each therapy sessions	Hospital day to first stand
		SOFA score at admission and cannulation	Therapy visit to first stand
		Charlson Index at admission	Grooming assist level each session
			AM-PAC "6-Clicks" Daily Activity Score each session
			Barthel Index score at evaluation

The principal investigator reviewed and verified all data entries for completeness and accuracy. The medical records of patients who met inclusion criteria were retrospectively reviewed (Table 1). The data were recorded with an electronic template and included demographic and medical characteristics known to impact a patient's medical outcomes to assess patient progress (Table 2). Functional outcomes were monitored throughout the Activity Measure for Post-Acute Care (AM-PAC) "6-clicks" daily activity assessment.

Table 2

Demographic Characteristics, Length of Stay in Hospital, Days on ECMO, Therapy Visits, and Discharge Location

Patient Number	Age (yrs)	Length of Stay (days)	Days on ECMO	Percentage of Days on ECMO	Number of OT sessions	Number of OT sessions on ECMO	Hospital Day to OT start	Discharge Location
1 ECMO	62	71	41	58	10	8	17	LTAC
2 ECMO	64	37	20	54	16	8	1	SNF
3 ECMO	53	13	11	85	7	5	5	Home
4 ECMO	51	59	25	42	13	6	8	IPR
5 ECMO	51	111	58	52	31	15	22	Home
6 Post-ECMO	50	19	8	42	5	N/A	14	Home
7 Post-ECMO	34	40	12	30	16	N/A	18	Home
8 Post-ECMO	51	69	41	61	14	N/A	45	IPR
9 Post-ECMO	45	19	10	53	4	N/A	14	IPR
10 Post-ECMO	50	47	7	15	12	N/A	8	LTAC
11 Post-ECMO	40	68	31	46	12	N/A	40	IPR

Note. LTAC= Long Term Acute Care Hospital, SNF= Skilled Nursing Facility, IPR= Inpatient Rehab Facility

The AM-PAC “6-Clicks” Daily Activity assessment is a multidimensional valid measurement that uses six questions to analyze functional outcomes of patients’ daily activities and mobility (Haley et al., 2004; Jette et al., 2015;). The AM-PAC has been validated for use in a variety of diagnoses and patient populations to measure difficulty and limitations in activities of daily living including bathing, dressing, toileting, eating, and grooming. The total raw score is 24 points with a possible score of one to four for each question. The lowest raw score on the Daily Activity Inpatient Short Form is six, indicating a Centers for Medicare & Medicaid Services (CMS) score of 100% debility, while the highest raw score is 24, and 0% debility. The AM-PAC scores can be converted into a t-score to quantify functional independence in both self-care and mobility as well as discharge destination for post-acute care needs functional ranges. They help identify current functional levels from a mobility and self-care completion standpoint as well as anticipated discharge destinations for post-acute care needs (Jette et al., 2014; Silphen & Green, 2017). The AM-PAC “6-Clicks” tool can be completed by a healthcare professional, the patient, family, or caregiver. It may be determined either by direct completion of by indirect clinical judgment (Haley et al., 2004; Jette et al., 2015).

Both the Charlson Comorbidity Index (CCI) and Sequential Organ Failure Assessment (SOFA) scores were calculated for day of admission, while only the SOFA score on the day of ECMO cannulation (Table 3) (Charlson et al., 1987; Vincent et al., 1996). The CCI estimates 10-year survival rate while the SOFA predicts mortality risk in the ICU (Charlson et al., 1987; Vincent et al., 1996).

Table 3

Charlson Comorbidity Index and Sequential Organ Failure Assessment

Patient	Charlson Comorbidity Index at admission	Sequential Organ Failure Assessment at Admission	Sequential Organ Failure Assessment at ECMO cannulation
1 ECMO*	0 points; 98% survival	2, > 6.4% mortality	9, > 6.4% mortality
2 ECMO	2 points; 90% survival	2, > 6.4% mortality	9, > 6.4% mortality
3 ECMO*	2 points; 90% survival	11, >50% mortality	11, >50% mortality
4 ECMO	2 points; 90% survival	N/A	4, > 20.2% mortality
5 ECMO*	2 points; 90% survival	2, > 6.4% mortality	9, > 33.3% mortality
6 Post-ECMO	0 points; 98% survival	4, > 20.2% mortality	11, >50% mortality
7 Post-ECMO	0 points; 98% survival	8, > 33.3% mortality	12, >95.2% mortality
8 Post-ECMO	0 points; 98% survival	5, > 20.2% mortality	10, >50% mortality
9 Post-ECMO	1 point; 96% survival	4, > 20.2% mortality	9, > 33.3% mortality
10 Post-ECMO*	0 points; 98% survival	10, >50% mortality	10, >50% mortality
11 Post-ECMO	2 points; 90% survival	7, > 21.5% mortality	13, >95.2% mortality

Note. *cannulated on day of admission

All patients were referred to OT by the ICU medical team and evaluations were initiated when deemed appropriate to participate in therapy intervention in collaboration with the multidisciplinary team. It was noted that some occupational therapy referrals were placed while the patients were on ECMO and others after decannulation. ABCDEF bundles were initiated by the ICU team and patients were referred to therapy for early

mobilization and exercise to reduce functional decline, impairments in self-care activities, or neurocognitive dysfunction (Table 4). With overall goal to prevent intensive care unit acquired weakness (ICUAW), delirium, and improve overall quality of life and recovery.

Table 4

ABCDEF Bundle

Acronym	Meaning
A	**A**ssess, prevent, and manage pain
B	**B**oth spontaneously awaken and trial breathing with less assistance
C	**C**onsider choice of analgesia and sedation
D	**D**elirium to assess, prevent, and manage neurocognitive dysfunction
E	**E**arly mobilization and exercise
F	**F**amily empowerment and engagement

Note. (Marra et al., 2017)

Protocols were developed by the physical medicine and rehabilitation COVID-19 taskforce at the quaternary care center, as well as the World Health Organization (WHO), Center for Disease Control (CDC), Infection Prevention and Control, American Occupational Therapy Association (AOTA), and American Physical Therapy Association (APTA) for treatment of COVID-19 positive patients. (CDC, 2020; Esbrook et al., 2020; Thomas et al., 2020; WHO, 2020).

Occupational therapy interventions through a Person-Environment-Occupation-Performance (PEOP) model, Occupational Adaptation (OA), Model of Human

Occupation (MOHO), and Canadian Model of Occupational Performance and Engagement (CMOP-E) were utilized with emphasis on biomechanical, cognitive-behavioral, and compensatory frame of references. This included facilitation of self-care activities, in-room functional mobility, mitigation of further neurocognitive dysfunction, environmental adaptations to the ICU room, mindfulness or stress management, and biofeedback. It also emphasized therapeutic exercise (to increase bilateral upper extremity strength), home safety and fall prevention, and adaptive equipment instruction.

Precautions for cannula and patient safety were followed during therapy interventions. These were established by cardiothoracic surgeons, ECMO specialists, and the critical care rehabilitation team. These precautions included avoiding shoulder flexion or abduction greater than 90 degrees, heavy lifting of 5-10 pounds to the upper extremity with the cannulation, ensuring proper anchors and securement devices prior to functional mobility, screening positional tolerance of cannulas with hip flexion prior to functional mobility, and implementing a mobilization checklist by ECMO specialists. This checklist includes the roles and order of operations in case a catastrophic event (decannulation or code event) occurred during the therapy session. Additional guidelines for safe progression of functional mobility with mechanical circulatory support were utilized. Use of upper extremities for ADL participation can be allowed within precautions. Use of a walker or other assistive device is allowed with an emphasis on primary weight-bearing through lower extremities and minimal use of upper extremities. Additionally, therapists followed laboratory, circuit, ventilator, and vital sign parameters set by the cardiothoracic surgery team, ICU team, and the Academy of Acute Care

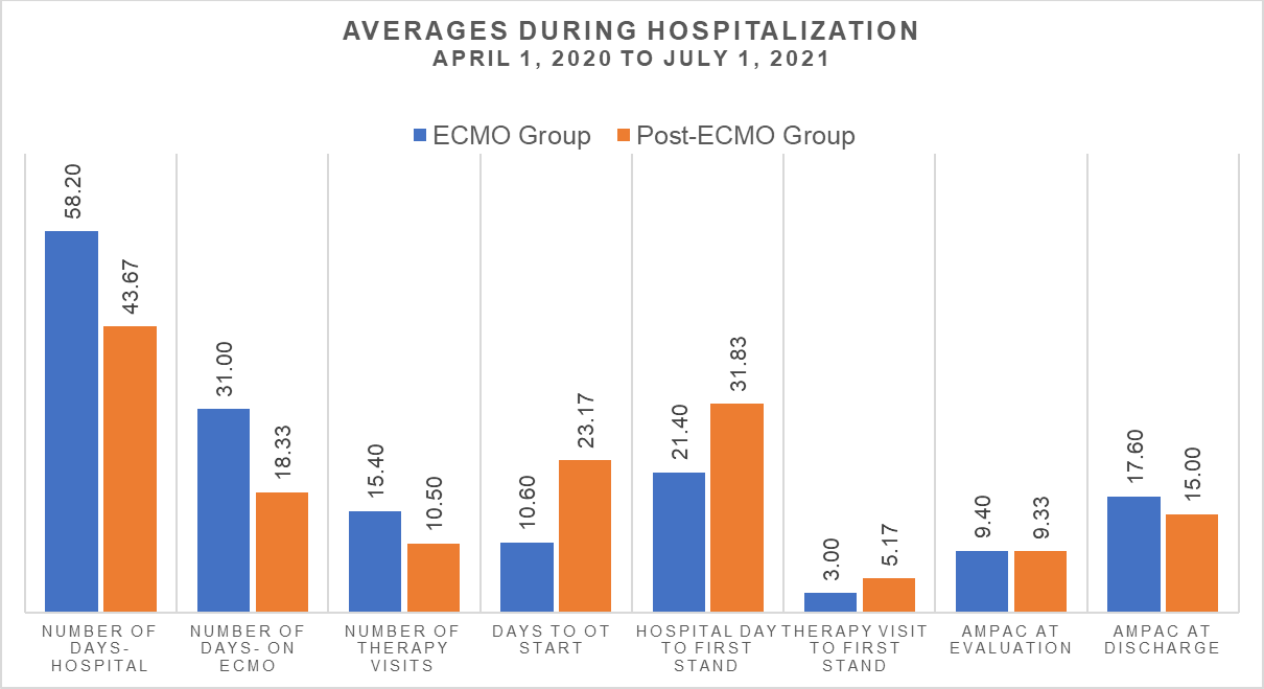
Physical Therapy Laboratory Values Interpretation Resource (Academy of Acute Care Physical Therapy, 2017).

Results

Length of stay for patients in both the ECMO and post-ECMO group ranged from 13 days to 111 days. The median length of stay for the ECMO group was 55.0 days while the post-ECMO group was 43.6 days (Figure 1). The COVID-19 ECMO group was cannulated longer at 27.0 median days (52% of hospital days) compared to post-ECMO group at 18.3 (41% of hospital days). Occupational therapy evaluation was initiated on median hospital day 13.3 for ECMO group and hospital day 23.2 for post-ECMO group. The ECMO group had more occupational therapy sessions on average: 13.2 sessions per hospitalization versus 10.5 sessions for the post-ECMO group (Figure 1). Patients treated on ECMO performed their first sit-to-stand on median hospital day 24.8, which was almost a week earlier than the post-ECMO group on hospital day 31.8 (Figure 1 and Table 5). Patients who were treated while on ECMO stood sooner in their therapy sessions (on session three versus session five for the post-ECMO group) to prepare for further occupational performance and ADL participation through functional mobility (Figure 1 and Table 5).

Figure 1

Hospitalization Averages



The overall AM-PAC “6-Clicks” daily activity scores improved by 40.4% for the ECMO group compared to 23.8% for the post-ECMO group with similar SOFA scores at cannulation (Figure 2 and 3). The ECMO group had a median raw score of 8.7/24 at evaluation and 18.4/24 at discharge suggesting home with home health and supervision as a safe option (Figure 2 and 3). Of the five patients in the ECMO group, two were discharged home, one to inpatient rehabilitation, one to a skilled nursing facility, and the other to a long-term care facility for ventilator weaning (Table 2). The post-ECMO group had a median raw score of 9.3/24 at evaluation and 15.0/24 at discharge suggesting discharge to short term rehab versus inpatient rehabilitation would be appropriate (Figure 2 and 3). Of the six patients in the post-ECMO group, two were discharged home, three to inpatient rehabilitation facilities, and one to a long-term care facility for ventilator weaning (Table 2).

Figure 2

Comparison of AM-PAC "6-Clicks" Daily Activity Score: Admission to Discharge

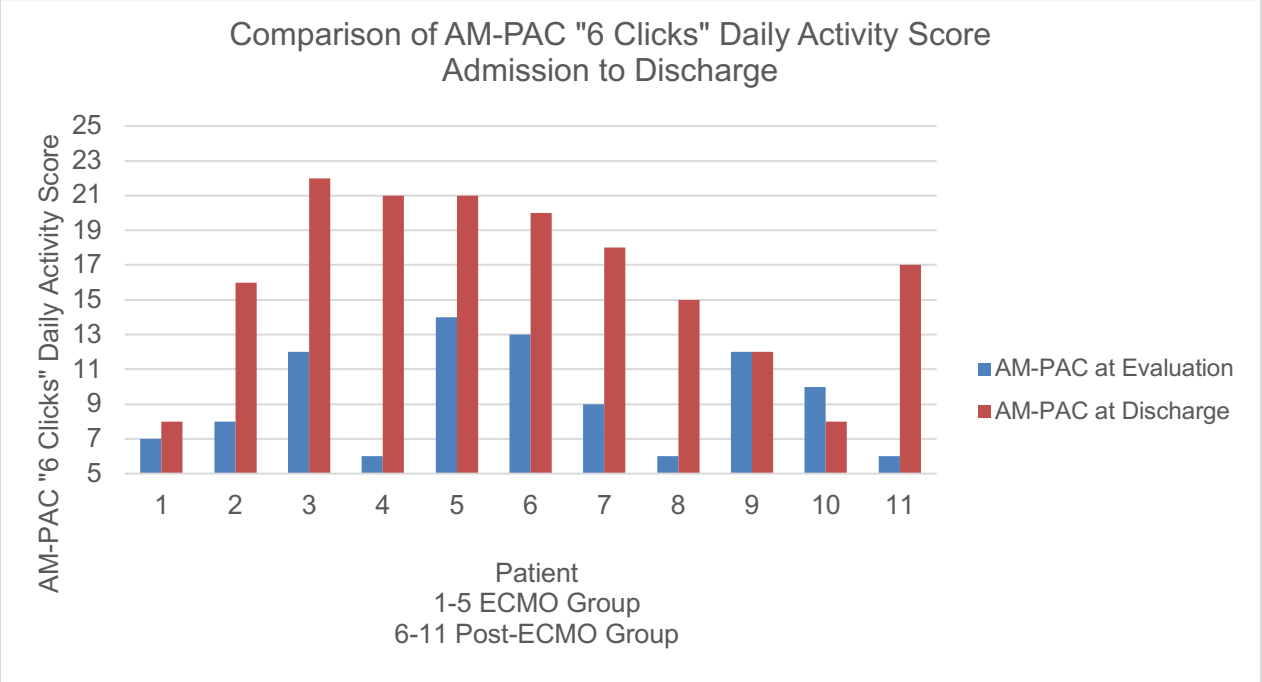


Figure 3

Change in AM-PAC "6-Clicks" Daily Activity Score: Each Therapy Session

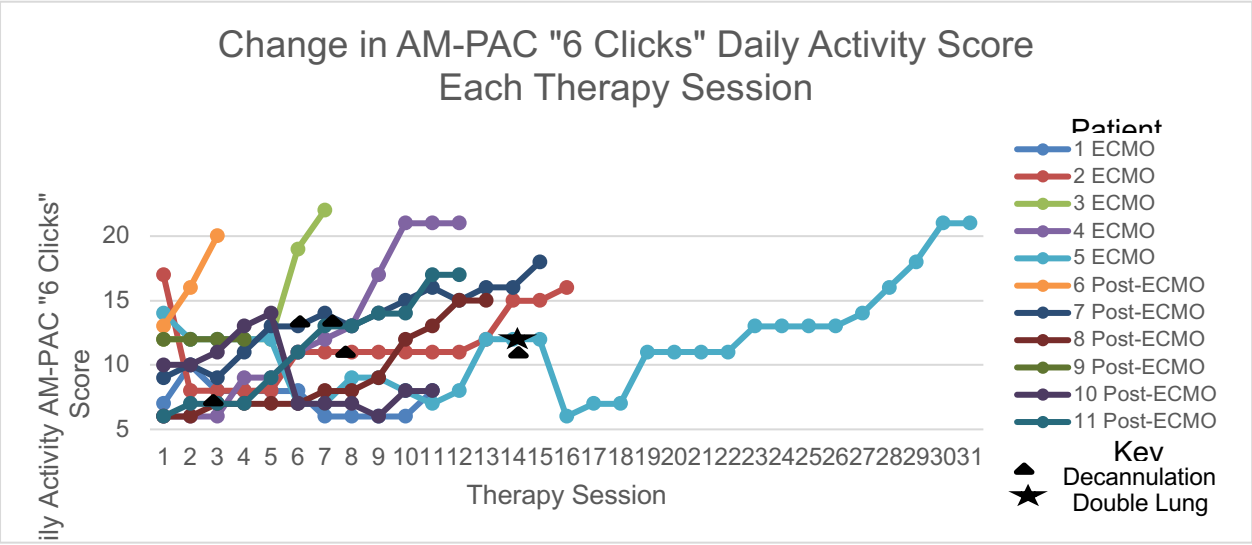


Table 5

Highest Level of Function Achieved while on ECMO

Patient Number	Highest Level of Functional Achieved While on ECMO	AM-PAC Daily Activity Score on ECMO (Highest Score)	AM-PAC Daily Activity Score at Discharge
1	● Sit-to-stand requiring moderate assistance of two for up to 90 seconds upright ● Seated ADLs requiring moderate assistance ● Upper extremity cycling for 10 minutes	10/24	8/24
2	● Sit-to-stand requiring minimum assistance of two for up to 120 seconds upright ● Seated ADLs requiring stand by assistance ● In room functional mobility 5 feet repeated 4 times with moderate assistance of two and rolling walker	11/24	16/24
3	● Sit-to-stand requiring minimum assistance of two for up to 10 minutes upright ● Standing ADLs chairside requiring minimum assistance ● Toileting on bedside commode with maximum assistance for perineal hygiene ● In room functional mobility 20 feet repeated 3 times with minimum assistance of two and rolling walker	12/24	22/24
4	● Sit-to-stand requiring moderate assistance of two for up to 30 seconds with rolling walker ● Standing ADLs requiring moderate assistance ● Tilt table up to 80 degrees and performing mini squats on table ● Toileting task on bedpan requiring total assistance for perineal hygiene	9/24	21/24
5	● Sit-to-stand requiring minimum assistance and minimum assistance x2 w/ rolling walker for transfers ● Standing yellow upper extremity exercises ● Out of room functional mobility 75 feet with podium walker and minimum assistance (COVID isolation precautions lifted) prior to double lung transplant	12/24	21/24

Note. Table demonstrating the functional capabilities and treatment plans of patients while on ECMO during OT sessions, patients 6-11 were not included in this table as they were not treated by OT while on ECMO

Discussion

The factors caused from critical COVID-19 illness, ARDS requiring mechanical ventilation, and ECMO can lead to severe ICUAW, isolation and ICU delirium, and decreased quality of life. This can affect all areas of daily activities and occupations which can lead to PICS (Spadaro et al., 2020). This necessitates ICU OT intervention to improve functional independence at discharge, improve discharge disposition, improve functional mobility at discharge, lower rates of neurocognitive disorders such as delirium and weakness, improve quality of life, and decreased duration of mechanical ventilation (Weinreich et al., 2017). Early OT intervention to promote occupational performance, for patients with and without advanced mechanical circulatory support, should be broadly utilized in critical care units for all patients that are appropriate through use of ABCDEF bundles and continued interdisciplinary teamwork and proper training.

At time of literature review, no studies examined the effects of ADL functional outcomes solely through OT intervention in patients requiring ECMO. Research exists for utilizing a multidisciplinary team approach in addition to research focusing on ambulation and physical therapy during early rehabilitation for patients on ECMO (Abrams et al., 2014; Dalia et al., 2019; Ferreira et al., 2019; von Stumm et al., 2016). This study reviewed and identified the importance of OT involvement to improve functional outcomes in patients requiring ECMO with COVID-19.

This pilot case series provides a focus on therapy involvement for critically ill patients with COVID-19 which addresses a gap in existing research given the novelty of the virus. The role of OT for critically ill patients with COVID-19, with and without mechanical circulatory support, is crucial. There are opportunities for OTs to expand

their ICU role to incorporate early intervention with advanced mechanical circulatory support such as ECMO. This requires additional training and education by therapists in order to provide safe, skilled, and timely intervention for this critically ill and unique population. Occupational therapists can continue to provide original research investigating the unique scope of practice within the ICU and ECMO.

This case series describes OT interventions and functional outcomes with the COVID-19 population requiring ECMO. There were no reported adverse outcomes during OT in the cases featured in this study. This study provides valuable information about length of stay, therapy plan of care, number of ECMO days, daily activity functional outcome scores through AM-PAC “6-Clicks”, functional mobility progression through first sit-to-stand, and post-acute care discharge destinations. Improvement in daily functional performance assessed through AM-PAC “6-Clicks”, decreased level of care required for post-acute care discharge destinations, and improved functional mobility was observed despite longer median length of stays and percentage of days on ECMO. At OT initial evaluation, the AM-PAC scores were lower for the ECMO group versus post-ECMO group; this finding suggests that greater functional recovery occurs through safe, skilled, and timely OT intervention while on ECMO (versus after decannulation).

Limitations

This case series had several limitations. Although it provides descriptive information of the OT course for patients in the ECMO and post-ECMO groups, the sample size was small which affects the ability to generalize study findings to the larger population. The sample size was limited by its single site and hospital census for

ECMO, specifically for patients with COVID-19 that survived hospitalization, and only provided data collection in adult acute care. Since data collection, the quaternary care center's COVID-19 ECMO numbers have more than tripled due to variant surges and numerous patients requiring bilateral lung transplants post COVID requiring ECMO bridge support. This data would be valuable for follow up studies to determine generalizations to a larger population.

OT was not consulted on six of the patients until after decannulation (post-ECMO group), data was not gathered regarding the possible functional outcomes while on ECMO. In addition, since OT intervention was part of routine care, multiple practitioners were involved in the care of these patients, and some patients frequently had different therapy providers. The variability of staffing may have affected the progression of the treatment plan and functional outcomes. Some patients had the Barthel Index measured at the time of evaluation, while others did not which affected consistency amongst data collection and was not included in analysis. Also, physical therapy was consulted on all of these patients which may have affected the functional outcomes including improvements with functional mobility. In addition, critical clinical conditions resulting in hemodynamic instability or sedation affecting participation in OT was the reason for missed visits which impacted the number of therapy sessions during hospitalization. The influence of missed and canceled visits on functional outcomes for this group is unknown.

Despite the high risk for neurocognitive dysfunction and delirium in this patient population, no consistent standardized assessment was used to assess cognition by therapy staff. The researchers concluded that due to barriers with communication while

on mechanical ventilation, reliable and valid cognitive outcome measures may not be consistent and were based on objective observation.

Future studies could improve on this research by consistently utilizing additional standardized assessments such as Barthel Index or Confusion Assessment Method for the ICU (CAM-ICU). Reasons for missed visits could be tracked including hemodynamic instability, sedation, or other procedures (such as hemodialysis) and determine how the number of therapy sessions and time spent improves functional outcomes. A larger sample size could be included in order to run power analysis.

Due to COVID-19, modified airborne and droplet isolation precautions were implemented by Infection Prevention and Control, which required specific personal protective equipment and all therapy treatment sessions to be performed in the patient's room with these isolation precautions. These contextual limitations required additional therapy modifications and restrictions to in-room treatments, which may have affected progression of the OT treatment plan and functional outcomes. Further research is required on the effects of modified therapy interventions requiring isolation precautions and functional outcomes.

Further research is needed on the functional outcomes of COVID-19 ECMO patients in post-acute care: their timeline to return to prior level of function, the effect that severe critical illness has on their long-term quality of life, and hospital readmission rates. Given the small amount of research published on the role of OTs in the ICU an emphasis on original research investigating the unique scope of practice within the ICU and ECMO is encouraged.

Practice Implications

This retrospective review identifies that early functional OT intervention improves AM-PAC “6-Clicks” daily activity score, decreases level of care required for post-acute care discharge destinations, and improves functional mobility. This is evident in the ECMO group data despite longer median length of stays and percentage of days on ECMO compared to the post-ECMO group. The role of OT in the ICU with mechanical circulatory support is important, leading to greater functional outcomes and decreasing the required level of care upon discharge. The role of OT should focus on ADL integration, delirium prevention, functional mobility, and activity tolerance to promote occupational performance. OT departments may benefit from establishing safety protocols, mobility checklists, and standardized outcome measures related to self-care performance and cognition for this patient population with collaboration of their intensive care interdisciplinary team.

Conclusion

The purpose of this retrospective case series was to identify functional outcomes for patients of two groups with COVID-19, one treated by OTs while on ECMO (ECMO group) and the other treated by OTs after decannulation (post-ECMO group). This review provided an overview of OT’s role including ADL integration, delirium prevention, and functional mobility, as well as functional outcomes with early intervention in the acute care setting (ECMO versus post-ECMO groups). This comparison revealed an increase in AM-PAC “6-Clicks” daily activity score by 16.6%, decreased level of support required post-acute care, and suggests that occupational therapy is valuable for the COVID-19 population requiring ECMO.

Additional research is needed on the outcomes of OT intervention with patients on ECMO. Future research should also explore the impact of occupational therapy on cognition for the ICU COVID-19 patient population. This research is necessary for occupational therapists in acute care to further develop early interventions with the critically ill population and continue to improve patient functional outcomes during hospitalization while maintaining safety.

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