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Walking While Dialyzing: A Retrospective Observation of Early Mobility and Ambulation for Patients on Continuous Renal Replacement Therapy

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Objectives: To describe the practice of physical therapy for patients requiring continuous renal replacement therapy and assess data related to the safety and feasibility of physical therapy interventions.
Design: A retrospective observational cohort study.
Patients: Surgical and cardiovascular patients receiving continuous renal replacement therapy during a 2-year period from December 2016 to November 2018.
Setting: Two ICUs at a single academic medical center.
Intervention: Physical mobility and ambulation while on continuous renal replacement therapy.
Measurements and Main Results: Therapy data including ICU Mobility Scale score, number of physical therapy sessions with and without ambulation and gait distance, along with safety data including filter life, safety events, and mortality were analyzed. The cohort of patients receiving continuous renal replacement therapy during the 2-year period was 206. Of these, 172 (83.49%) received simultaneous physical therapy. The median ICU Mobility Scale was 5 (interquartile range, 4–7) over a total of 1,517 physical therapy sessions. Ambulation with concomitant continuous renal replacement therapy connected was achieved in 78 patients (37.86%). There were 377 ambulation sessions (24.85% of all sessions) with a mean of 4.83 (SDS 4.94) ambulation sessions per ambulatory patient. Patients walked an average of 888.53 feet (SD 1,365.50) while on continuous renal replacement therapy and a daily average of 150.61 feet (SD 133.50). In-hospital mortality was lowest for patients who ambulated (17.95%) and highest for patients who received no therapy (73.53%). Continuous renal replacement therapy filter life was longest for patients who ambulated (2,047.20 min [SD 1,086.50 min]), and shortest in patients who received no therapy (1,682.20 min [SD 1,343.80 min]). One safety event was reported during this time (0.0007% of all physical therapy sessions).
Conclusions: Ambulation while on continuous renal replacement therapy was not associated with an increased risk of safety events and was feasible with the use of nonfemoral catheters and dialysis equipment with internal batteries.
Key Words: ambulation; critically ill; early mobility; physical therapy; renal replacement therapy

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The negative consequences of immobility during a hospital stay and the benefits of physical therapy (PT) have been well documented (1–5). As medical care has gotten more complex, so too have the mobility interventions provided to these patients. Although the presence of extracorporeal support devices may have excluded a patient from mobilizing in the past, recent studies support the notion that mobility, including ambulation, may be safe for critically ill patients (1, 6–10). This includes patients on devices including mechanical ventilation, extracorporeal membrane oxygenation (ECMO), and temporary ventricular assist devices (6, 11–15).

Less is known about the feasibility of ambulation for patients requiring continuous renal replacement therapy (CRRT). CRRT is used for the management of acute kidney injury (AKI), particularly in patients with relative hemodynamic instability who may not tolerate more traditional intermittent hemodialysis (16). These patients are of high medical acuity with up to a 50% mortality, and those surviving carrying a high degree of morbidity (17, 18). It is suggested that mobilizing these patients may put them at risk for complications including, catheter dislodgement, especially for femorally placed catheters, hemodynamic instability, and interruptions to the renal replacement therapies (19–21). Thus, these patients are often excluded from mobility interventions despite also being at high risk for complications related to immobility.

A subset of published research has focused on the feasibility of mobility with femorally placed catheters (21, 22). Previous research supports the safety of mobilizing with these catheters in place, but do not specifically discuss ambulating with the catheter actively in use (19, 21, 22). Techniques for ambulating patients requiring CRRT typically include a saline recirculation procedure for temporary disconnection from the equipment (20). Although this is possible, the process can be time-consuming and is often reserved for traveling to diagnostic testing and procedures. Further, this causes disruption to dialysis therapy, thus impacting the effectiveness of the treatment, and can, therefore, be an additional cost to patients (20). For these reasons, finding ways to ambulate without disconnecting from the equipment may be beneficial.

Previous studies have supported the feasibility of basic mobility while connected to a CRRT device (19, 22–27). Literature that describes higher-level mobility interventions, however, are limited in quantity, with few studies describing mobility beyond standing or marching in place. Mayer et al (27) describe progressing mobility only when disconnected from the CRRT machine, while Brownback et al (23) described ambulation while still connected to CRRT, but only for a single case. Small sample sizes of previous studies have also limited the ability to assess the risk of complications from higher levels of mobility. Both Talley et al (25) and Mayer et al (27) reported less than 3%, and Toonstra et al (26) reported 0% of study populations progressing to ambulation.

Due to the lack of research on the topic of PT interventions, and in particular ambulation for patients requiring CRRT, it is important to continue to examine the extent of mobility that may be possible. This study aims to look specifically at two ICUs within an academic medical center in which the use of active PT, including ambulation, with extracorporeal devices in critically ill patients is common. We aim to describe the level of PT and mobility interventions provided as standard care to these patients, current medical practices that facilitate increased mobilization, and discuss the potential implications in determining the feasibility and safety of such practices. To the authors' knowledge, this is the first study of its size examining the practice of ambulating while still connected to a CRRT device.

MATERIALS AND METHODS

This was a retrospective observational study of a specific cohort of patients receiving CRRT while admitted to a single academic medical center from December 2016 to November 2018. PT team staffing counts for the 20 bed cardiovascular ICU (CVICU) and 12 bed surgical ICU (SICU) included 7 full-time PTs, whose shifts provided 7 days per week coverage. This study was approved by the Institutional Review Board (IRB00084463).

Inclusion criteria included patients 18 years or older admitted to the CVICU or the SICU who received CRRT. Patients were excluded if they received CRRT care on a different unit, as it was not standard of care to mobilize these patients on other units.

Data were obtained from the University of Utah Health Enterprise Data Warehouse (EDW). The EDW is a collection of electronic databases that house data collected from day to day operations at the University of Utah Hospitals and Clinics that has been previously validated for research (28, 29). Patients were initially identified through a query of the EDW for patients within the study time frame that had any documented CRRT measures recorded. Demographics, mobility information, CRRT values, disease severity, and encounter variables were included in the query. A manual chart review was performed on the identified patients to obtain details about PT sessions, including gait distance per session and the number of PT sessions while on CRRT. In order to determine if safety events occurred relating to CRRT and PT interventions, the hospital system for event reporting was retrospectively reviewed for the timeframe of the study. Events recorded in this database include events such as dislodgement of catheters, falls, medical emergencies such as cardiac or respiratory arrest, failure of equipment, or injury to patients or staff. Due to the retrospective nature of the study, the adverse events were limited to those major events reported in this database and did not include lesser events often obtained in prospective studies such as acute desaturation, hypotension, or dysrhythmias during mobility. This analysis is reported according to the Strengthening the Reporting of Observational Studies in Epidemiology guidelines (30).

Treatment Interventions

Patients requiring CRRT for treatment of their AKI typically have a dialysis catheter placed either into their subclavian or internal jugular veins for access. Alternatively, it is also possible to connect access into other temporary devices such as ECMO, or right ventricular assist devices. Femorally placed catheters have historically been a common access site; however, they have been found to be associated with an increased risk of catheter kinking, bleeding, thromboses, loss of access, or infection (22). Recent studies assessing the feasibility of mobility on CRRT by Mayer et al (27) and Toonstra et al (26) report only 9% and 1% of their respective cohorts having femoral dialysis catheters. As catheter location is left to the discretion of the medical team, physicians at the study site choose to refrain from placing femoral catheters whenever possible to promote increased early mobility and rehabilitation in the ICU. In our study cohort, no patients had femoral dialysis catheters. Catheters included Niagara (Bard Access, Salt Lake City, UT) Slim-Cath (15 or 20 cm, 12F), Arrow (Teleflex, Morrisville, NC) catheter (15 cm or 20 cm, 14F), or Arrow Trialysis catheter (Teleflex) (16 cm, 12F). Catheters are secured in place using two sutures per standard protocol and then are covered with a sterile central line dressing.

Catheters were connected to a Prismaflex System for Critical Care (7.11) by Baxter International (Deerfield, IL) with an M100 model filter in use. The current Prismaflex systems have an internal battery life of 10+ minutes, as described in manufacturer literature that allows for unplugging from alternating current (AC) power for short durations. It is standard practice on these units to mobilize patients while still receiving CRRT rather than stopping CRRT and disconnecting from the Prismaflex machine. Machines are routinely plugged back into AC power during rest breaks to conserve battery power. Additionally, machines give a 15-second warning prior to the loss of power, which affords enough time to reach an AC outlet as needed. The out-of-room portion of sessions is limited to avoid loss of power, and sessions occur on units where outlets are placed every 15 feet for safety. These safety measures ensured that no loss of circuit or loss of blood occurred during ambulation.

Patients received a PT consultation from the covering medical team for evaluation and treatment if indicated. PT interventions were provided as tolerated, with the progression of activity level following a stepwise algorithm previously described (6). In this protocol, patients are progressed through in-bed mobility, edge-of-bed mobility, standing activity, and dynamic standing activity as tolerated physically and medically, including those in need of extracorporeal support (6).

For all patients mobilizing on CRRT, several steps were taken to ensure safety. A registered nurse trained to manage the CRRT machine was present for ambulation to manage the device and assess for potential safety issues. A single staff member was used to mobilize the CRRT machine with the standard practice being to keep the CRRT machine to be in front of the patient during transfers or hallway ambulation to minimize the risk of catheter dislodgement as shown in (**Fig. 1**). This positioning also facilitates ease of mobility due to a handle on the back of the device, providing an optimal contact point for moving the sizeable rolling machine without difficulty. Patient hemodynamics were continuously monitored on a portable telemetry monitor, and patient response to activity was routinely assessed before, during, and after any mobility intervention.

Assessments and Outcome Measures

A description of the PT session and interventions provided was documented into the electronic medical record (EMR) each session by the treating physical therapist. Data included gait distance per session and a recorded ICU Mobility Scale (IMS) score, which is described in (**Fig. 2**) (31). The IMS is an objective measure that describes the highest level of mobility achieved by the patient during the session.

Figure 1. A patient ambulating with assistance while receiving dialysis.

The primary outcome in this study was a patient achieving ambulation, defined as a score of greater than or equal to 7 on the IMS while requiring CRRT. Secondary outcomes related to PT interventions for each patient included gait distance, number of PT sessions while on CRRT, and number of PT sessions that included ambulation while on CRRT. Data relating to the function of the CRRT machine was also analyzed retrospectively to assess the life, or duration of therapy, per dialysis filter. This information is routinely charted by nursing staff in the same EMR. Analysis of mobility and filter data was limited to periods during which CRRT was performed.

Statistical Analysis

Descriptive statistics, including percentages, counts, means, and SDs, were used to describe patient, encounter, and CRRT characteristics.

RESULTS

Of all patients admitted to the CVICU or SICU during the timeframe of this analysis, 206 patients required CRRT for some duration. Patient characteristics were similar for all cohorts with regards to age, gender, and degree of comorbidity, as described in (**Table 1**). Of these patients, 78 (37.86%) had gait distances recorded, indicating that they ambulated while requiring CRRT. The median IMS was 5 (4–7). Patients participated in a total of 1,517 PT sessions, of which 377 included ambulation. (**Fig. 3**) depicts the percent of sessions accomplished at each IMS score. Patients who did ambulate were able to ambulate a mean of 4.83 (SD 4.94) times with a daily average of 150.61 feet (SD 133.5) while on CRRT. These outcomes are summarized in (**Table 2**).

There was one safety event (cardiac arrest) on CRRT during therapy (0.0007% of all mobility sessions), which occurred while the patient was on a commode. After a review of the event as part of regular quality control, it was determined that the safety event was not directly related to the presence of the CRRT machine. In-hospital mortality was lowest (17.95%) for patients who ambulated, higher (35.11%) for patients who mobilized but did

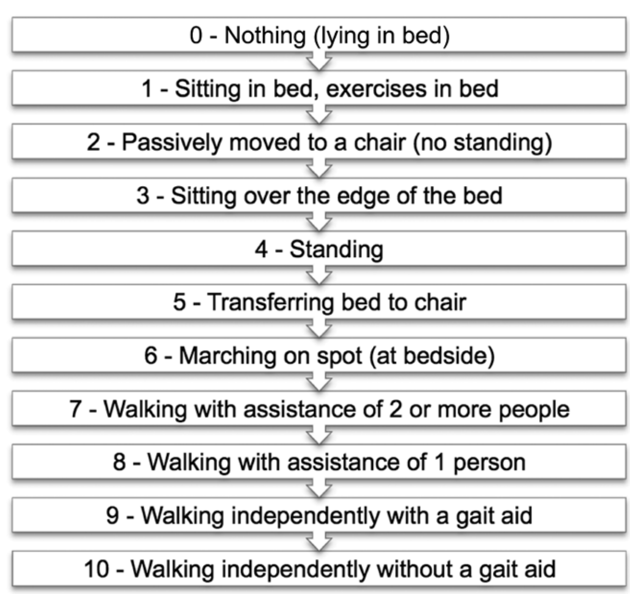

Figure 2. ICU Mobility Scale descriptors as described by Hodgson et al (31).

TABLE 1. Demographics of Patients Requiring Continuous Dialysis During Study Period

Demographic	Total, *n* = 206	No Therapy, *n* = 34	Therapy, No Ambulation, *n* = 94	Ambulation, *n* = 78
Male, *n* (%)	139 (67.5)	23 (67.6)	58 (61.7)	58 (74.4)
Age (yr)	57.4 (14.3)	52.9 (16.9)	58.9 (13.8)	57.6 (13.5)
Charlson Comorbidity Index	4.6 (2.8)	4.1 (2.6)	4.5 (3.0)	5.0 (2.8)
Hospital length of stay (d)	30.9 (24.8)	14.8 (19.4)	31.6 (24.8)	37.1 (24.1)
Total time on continuous renal replacement therapy (d)	11.8 (14.1)	3.0 (3.1)	12.4 (13.8)	14.8 (15.8)
Alive at hospital discharge, *n* (%)	134 (65)	9 (26.5)	61 (64.9)	64 (82.1)
Discharge disposition, % (*n*)				
Home	7.3 (15)	5.9 (2)	3.2 (3)	12.8 (10)
Inpatient rehab facility	17.0 (35)	2.9 (1)	22.3 (21)	16.7 (13)
Hospice/expired	37.4 (77)	76.5 (26)	37.2 (35)	20.5 (16)
Home health	11.7 (24)	0.0 (0)	7.4 (7)	21.8 (17)
Long-term acute care	11.7 (24)	2.9 (1)	17.0 (16)	9.0 (7)
Hospital/other	7.8 (16)	2.9 (1)	5.3 (5)	12.8 (10)
Skilled nursing facility	4.4 (9)	2.9 (1)	4.3 (4)	5.1 (4)
Unknown	2.9 (6)	5.9 (2)	3.2 (3)	1.3 (1)

not achieve ambulation, and highest (73.53%) for patients who received no mobility interventions.

For the study period, the mean filter life was 2,047.20 minutes (±1,086.50 min) for patients who ambulated, 1,943 minutes (±1,091.70 min) for patients who mobilized but did not achieve ambulation, and 1,682.20 minutes (±1,343.80 min) for patients who received no therapy.

DISCUSSION

Herein we present a cohort of patients participating in mobility interventions with a significant proportion progressing to hallway ambulation while receiving CRRT. Progressing mobility as tolerated while on CRRT has been implemented as a standard of care at this institution. Patients who did not progress to ambulation may have had had hemodynamic instability, rigid femoral catheters, or significant functional impairments that limited mobility. The low frequency of safety events supports the notion that progressing more patients to hallway ambulation is safe. In addition to multidisciplinary teamwork and close hemodynamic monitoring of patients, decisions regarding line placement and equipment allowed for higher levels of mobility than has been previously described in the literature. The decision to avoid femoral dialysis catheter placement and the presence of internal battery support on the dialysis equipment may increase the feasibility of this practice for patients on CRRT. The benefits of having internal power described by this research paper should be considered by both manufacturers and hospitals in the future. Making these devices compatible with mobilization likely has not been considered previously because the basic feasibility of ambulating with the dialysis equipment has yet to be established. In this study, patients did not require a disconnection from the circuit in order to ambulate.

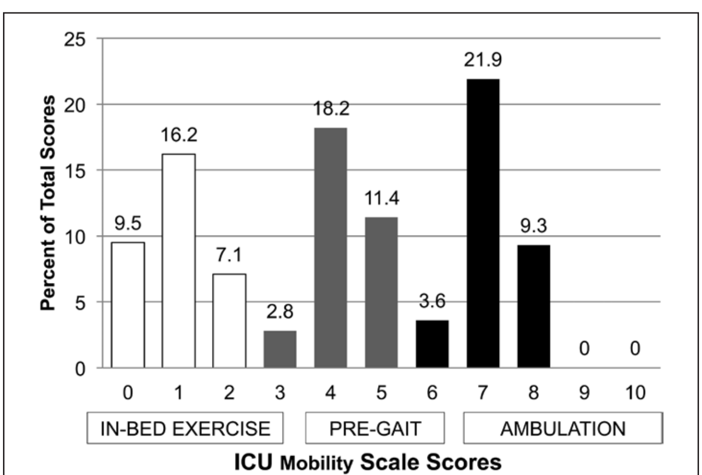

Figure 3. Percent of recorded scores at each level of the ICU Mobility Scale.

Ambulating, while connected to the dialysis machine, as opposed to disconnecting during therapy sessions, is advantageous for several reasons. Leaving patients connected to the CRRT machine saves time; it takes a registered nurse approximately 20 minutes to recirculate the blood back to the patient before disconnection and another 20 minutes to restart the circuit after disconnection. Recirculation also affects the total duration of dialysis in a day. If the patient participates in a 20-minute ambulation session, in addition to the 40 minutes to disconnect and reconnect, it results in up to an hour not being dialyzed. If the goal is to ambulate twice a day, in a week's time, that

TABLE 2. Physical Mobility and Mortality Outcomes for Cohort Patients, by Therapy and Ambulation Status

Outcome	No Therapy, $n = 34$	Therapy, No Ambulation, $n = 94$	Ambulation, $n = 78$
Alive at hospital discharge, *n* (%)	9 (26.5)	61 (64.9)	64 (82.1)
Average interval of CRRT circuit per patient (min)[a]	1,682.2 (1,343.8)	1,943.7 (1,091.7)	2,047.2 (1,086.5)
Highest achieved IMS score	NA	3.3 (2.1)	7.4 (0.7)
Number of IMS scores per patient	NA	6.6 (8.8)	10.3 (11.7)
Total therapy sessions on CRRT	NA	7.3 (9.9)	10.7 (10.1)
Number of sessions with ambulation	NA	NA	4.8 (4.9)
Total walking distance while on CRRT (feet)	NA	NA	888.5 (1,365.5)
Walking distance per day (feet)	NA	NA	150.6 (133.5)

CRRT = continuous renal replacement therapy, IMS = ICU Mobility Scale, NA = not applicable.
[a]Excludes terminal change.

adds up to 14 hours that a patient is not being dialyzed due to participation in mobility interventions. This may translate to the patient needing an increase in the overall duration of dialysis therapies to obtain the full benefit of the treatment and may lead to consequences related to their overall medical course (20). Further, as early mobility has been shown to decrease hospital length of stay, providing such interventions to patients on CRRT may lead to cost-saving benefits to both the patient and the hospital (6).

Although the data demonstrate that filter life was longer in patients who are mobilizing, we did not draw any causal inferences from this, as many other factors including anticoagulation, intrinsic clotting factors, degree of comorbidities, and medical management are likely to affect the filter life (19). It is suspected that patients who are more medically stable may experience improved filter life and are more likely to tolerate higher levels of mobility. Further research into this relationship is warranted.

Limitations

The retrospective cohort design should be taken into consideration when interpreting results. We lacked a control group to determine if safety events were statistically increased by participating in these interventions. A prospective study design may have provided information about patient hemodynamics during each session for a more detailed analysis of patient response to interventions. This information would likely increase the number of safety events reported because it would include more minor events such as acute hemodynamic changes, machine alarms, and patient response. Further, the described interventions were specific to standard care and equipment available at a single institution, which may impact the external validity of the findings.

Future Directions

Future research should examine the functional outcomes associated with mobilizing patients requiring CRRT. Further work should be done to demonstrate the effects of early mobility for patients on other types of extracorporeal support and continue to bring light to the potential negative consequences, both physical and psychosocial, of immobility in this patient population. Additionally, a well-designed prospective study of ambulating on CRRT may provide more detailed information about treatments than those described in this study.

This study suggests that specifications related to the dialysis equipment, such as battery power, may be a factor in determining if a patient can ambulate while receiving dialysis. Although the study suggests that this is a feasible practice with the equipment described, this could be an area of future investigation for those involved in the continual improvement of such devices. Adapting equipment may prove beneficial for various reasons beyond providing the opportunity for increased access to early mobility.

CONCLUSIONS

Although some literature exists to suggest that in-bed or bedside mobility is feasible, no significant data have yet been published to support the feasibility of more extensive out of bed activity, including ambulation while on CRRT. By describing the level of mobility achieved, CRRT filter life, number of associated safety events, and mortality, we conclude that PT interventions, including ambulation, for patients receiving CRRT may be both feasible and safe.

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Drs. Bento, Dummer, and Tonna all had full access to all the data in the study, takes responsibility for the integrity of the data, the accuracy of the data analysis, and the integrity of the submission as a whole, from inception to published article. Dr. Bento conceived the study design. Drs. Tonna and Dummer contributed to data acquisition and analysis. Drs. Bento and Dummer drafted the work. All authors revised the article for important intellectual content, had final approval of the work to be published, and agreed to be accountable for all aspects of the work.

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