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Rehabilitation therapy and outcomes in acute respiratory failure: An observational pilot project

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Abstract

Purpose: The aim of this study was to describe the frequency, physiologic effects, safety, and patient outcomes associated with traditional rehabilitation therapy in patients who require mechanical ventilation.

Materials and Methods: Prospective observational report of consecutive patients ventilated 4 or more days and eligible for rehabilitation in a single medical intensive care unit (ICU) during a 13-week period was conducted.

Results: Of the 32 patients who met the inclusion criteria, only 21 (66%) received physician orders for evaluation by rehabilitation services (physical and/or occupational therapy). Fifty rehabilitation treatments were provided to 19 patients on a median of 12% of medical ICU days per patient, with deep sedation and unavailability of rehabilitation staff representing major barriers to treatment. Physiologic changes during rehabilitation therapy were minimal. Joint contractures were frequent in the lower extremities and did not improve during hospitalization. In 53% and 79% of initial ICU assessments, muscle weakness was present in upper and lower extremities, respectively, with a decreased prevalence of 19% and 43% at hospital discharge, respectively. New impairments in physical function were common at hospital discharge.

Conclusions: This pilot project illustrated important barriers to providing rehabilitation to mechanically ventilated patients in an ICU and impairments in strength, range of motion, and functional outcomes at hospital discharge.

1. Introduction

Survivors of critical illness frequently have significant muscle weakness and related functional impairment that may persist for years after intensive care unit (ICU) discharge [1,2]. The etiology of this weakness is multifactorial,

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including preexisting weakness before hospitalization, ICU-acquired neuromuscular abnormalities, and immobility due to bed rest in the ICU [3,4]. Intensive care unit–acquired neuromuscular abnormalities (critical illness polyneuropathy, critical illness myopathy, or both) are very common, particularly in patients with sepsis, multiorgan dysfunction, or prolonged mechanical ventilation [5]. Evidence-based strategies for preventing muscle weakness are limited, with avoidance of hyperglycemia having the greatest support [5-7]. However, early activity and rehabilitation in the ICU may play an important role in preventing the known adverse affects of immobility, including muscle atrophy and weakness, connective-tissue shortening, and general deconditioning [8-13].

Rehabilitation in the ICU setting is particularly relevant for patients who require mechanical ventilation because they frequently experience little or no activity or mobility while in the ICU [14]. In preliminary studies, an intensive, early mobility approach to mobilizing mechanically ventilated ICU patients appears to be safe, feasible, and beneficial [15-18]. However, this approach is not common practice in most ICUs, and patients generally remain immobile throughout their ICU stay [11,14]. Thus, a better understanding of rehabilitation frequency, barriers, and outcomes in traditional ICUs (ie, those ICUs without an early mobility program) is required. Consequently, we observed rehabilitation practices and associated patient outcomes in our traditional ICU with the following objectives: (1) to describe the frequency, physiologic effects, and safety of routine rehabilitation therapy in mechanically ventilated patients and (2) to longitudinally report changes in muscle strength, range of motion (ROM), and physical functional status during hospitalization.

2. Methods

2.1. Background

Preliminary data from a multisite observational cohort study of long-term outcomes after acute lung injury [19,20] made physicians in our ICU aware of the potential need for quality improvement regarding delivery of routine rehabilitation therapy services to minimize impairment in patients' physical function during their ICU stay. This motivation served to stimulate the objectives for this project. A description of this observational project was provided to the Johns Hopkins Institutional Review Board, which deemed it to be a quality improvement project not requiring institutional review board review or approval.

2.2. Patients

During a 13-week period from January 29 to April 30, 2007, we observed consecutive patients receiving mechanical ventilation for more than 4 days in the 16-bed medical ICU (MICU) within a large inner-city, university hospital in Baltimore, MD. Patients were excluded if they: (1) were unable to understand or speak English; (2) were not independent with transfers before hospitalization; (3) required chronic mechanical ventilation before hospitalization; (4) had known neurologic disease affecting muscle strength (eg, myasthenia gravis and multiple sclerosis) at MICU admission; (5) transferred to the MICU from another ICU after more than 4 consecutive days of mechanical ventilation; (6) were awaiting potential transfer to the surgical ICU (eg, awaiting organ transplant); (7) were moribund; or (8) were anticipated to be discharged from the MICU within 48 hours.

2.3. Patient and ICU-related measurements

Patient data were abstracted from the medical record, including demographics, comorbid diseases, and ICU admission diagnosis. Severity of illness was measured using the Acute Physiology and Chronic Health Evaluation (APACHE) II scoring system [21]. While in the ICU, data on patients' sedation and delirium status and corticosteroid use were recorded daily. Sedation and delirium status were measured using the Richmond Agitation-Sedation Scale [22] and the Confusion Assessment Method for the ICU [23], respectively. All systemic corticosteroid use was converted to a prednisone-equivalent dose using standard conversion factors [24].

2.4. Rehabilitation interventions and physiologic measurements

The number of consultations made to physical therapy (PT) and occupational therapy (OT) as well as the total number and duration of routine rehabilitation treatments in the ICU were recorded. Initial evaluations by PT and/or OT would generally occur within 24 to 48 hours of physician consultation. Similar to many hospitals, therapists managed patient caseloads on multiple units and were not available to exclusively assess and treat patients in the MICU. Any barriers that precluded rehabilitation treatments were documented according to prospectively defined criteria. Rehabilitation interventions were individualized to each patient's impairments and included activities such as stretching, strengthening, balance training, and functional activities. The types of functional activities performed during treatment sessions were recorded, including (1) rolling, (2) sitting at the edge of the bed, (3) transferring from sitting to standing, (4) ambulation, (5) grooming, and (6) bathing. We also recorded the presence of endotracheal tubes and/or venous and arterial catheters during rehabilitation sessions. Physiologic measurements, including heart rate, blood pressure, and oxygen saturation via pulse oximetry (Sp_{O_2}), were recorded at the beginning and end of each routine treatment session.

Throughout therapy, heart rate and Sp_{O_2} were continuously monitored, with the maximum heart rate and lowest Sp_{O_2} lasting more than 1 minute recorded.

2.5. ROM and muscle strength measurements

During hospitalization, assessments of patients' physical and functional status were performed as part of routine clinical care in those patients with a physician order for PT/OT. Joint ROM, manual muscle testing (MMT), and functional status were recorded at 3 time points: ICU initial assessment (ie, upon patient awakening and obeying simple commands), ICU discharge, and hospital discharge. Range of motion was measured bilaterally for the following joints: shoulder, elbow, wrist, hip, knee, and ankle using a goniometer according to standard technique [25]. Joint ROM was considered to be "limited" if the measurement differed by more than 5 degrees from the established normative value [26]. For all limited joints, a standard contracture index score [27] was calculated as a measure of the severity of limitations in ROM. This index is a proportion that is calculated as the actual ROM divided by the joint's normative ROM value. For each individual patient, an overall contracture index score was calculated as the average of the contracture index for each joint with a limited ROM. Patients with more than 50% missing data were excluded from this overall score. In cases where a patient demonstrated a negative ROM (ie, a knee-flexion contracture where knee extension ROM would be −10 degrees), the contracture index was assigned the worst possible score (ie, 0%).

Manual muscle testing, which evaluates muscle strength via a standardized physical examination, was performed on 5 bilateral muscle groups in upper extremities (shoulder flexion, wrist and elbow, flexion and extension) and 7 bilateral muscle groups in the lower extremities (hip flexion, extension, and abduction; knee flexion and extension; and ankle dorsiflexion and plantarflexion). Manual muscle testing scoring was performed using the 6-point Medical Research Council scale ranging from 0 (no palpable muscle contraction) to 5 (normal muscle strength) [28,29]. A composite MMT score was calculated by summing the individual scores for each muscle group bilaterally for a total possible score of 50 for the upper extremity and 70 for the lower extremity. Clinical weakness was defined as a composite MMT score less than 80% of the maximum possible score, as in prior ICU studies [30-33]. When calculating the composite MMT score, if data were missing for 1 muscle group (eg, due to a radial arterial catheter limiting testing of one wrist), the MMT score for the contralateral muscle group was substituted given that ICU-acquired weakness affects left and right sides similarly [30]. If MMT data were missing bilaterally for a muscle group, it was imputed using the average score from the other muscle groups for purposes of calculating the composite MMT score only. A composite MMT score was not reported for patients who had more than 50% of MMT data missing.

2.6. Functional status measurements and outcomes

Each patients' physical functional status was assessed via a Functional Status Score for the ICU (FSS-ICU), which uses a scoring system based on the validated Functional Independence Measurement (FIM) [34,35]. This scoring system rates a functional activity between 1 (total assist) and 7 (complete independence). A score of 0 was assigned if a patient was unable to perform a task, due to either physical limitation or medical status. Similar to the FIM, patient's prehospitalization baseline functional status was collected retrospectively by interview with the patient and/or an immediate family member who was knowledgeable regarding the patient's functional status [34,35].

Only 3 of the 18 functional activities specifically evaluated by the FIM are feasible in ICU patients and evaluated in this report: grooming, bathing, and ambulation. Four other functional tasks relevant to the ICU setting were also evaluated in a similar manner: (1) rolling, (2) transfer from supine to sit, (3) sitting at the edge of bed, and (4) transfer from sit to stand. These 4 tasks, plus ambulation, were combined in the cumulative FSS-ICU, which is a simple sum of the 5 individual scores. For the first 6 eligible patients, the "transfer from supine to sit" task was not formally evaluated at the start of the project. In these 6 patients, for purposes of calculating the cumulative FSS-ICU, "transfer from supine to sit" was imputed using the score for "rolling," as a review of the existing data indicated similar scores for these tasks. Any other missing data for individual tasks were assigned a score of zero.

In addition to these scores, we collected 2 other functional measures: (1) the duration of unsupported sitting at the edge of the bed and (2) the maximum distance ambulated. A patient was scored as "unlimited" if they could sit for more than 30 minutes or ambulate more than 600 ft, and scored as zero if unable to sit or ambulate at all.

The number of assessments for joint ROM, strength, and functional status vary across the longitudinal assessments due to patient mortality, ICU readmission in 1 patient who had repeat ICU initial and discharge assessment, and incomplete assessments due to unavailability of rehabilitation staff or patient factors.

2.7. Unexpected events and patient outcomes

Any unexpected event during each treatment session was prospectively recorded. These events were defined a priori and included fall to knees or ground, loss of consciousness, sustained Sp_{O_2} <85% for more than 3 minutes, cardiac arrest, or dislodgement of any of the following medical equipment: (1) endotracheal tube, (2) feeding tube, (3) urinary bladder catheter, (4) chest tube, (5) arterial catheter, (6) venous catheter, (7) hemodialysis catheter, or (8) other catheter, tube, or drain (eg, rectal tube). Outcome data (mortality, ICU

length of stay, and discharge location) were abstracted from the patient medical record.

2.8. Statistical analysis

Data are presented using descriptive statistics, including proportions for binary and categorical data, and median and interquartile range (IQR) for continuous data. Median values were compared using the Wilcoxon rank-sum test, and proportions were compared using Fisher exact test, using Stata statistical software version 10.0 (Stata Corporation, College Station, Tex).

3. Results

A total of 54 MICU patients were identified as requiring mechanical ventilation for 4 or more days during the 13-week period. Of these patients, 32 met our eligibility criteria (Fig. 1). Patient characteristics are described in Table 1. Patients had a median (IQR) age of 49 (42-57) years. Most patients (69%) had a MICU admission diagnosis of a respiratory disorder. The median (IQR) APACHE II score was 27 (21-30). During daily Richmond Agitation-Sedation Scale and Confusion Assessment Method for the ICU assessments, patients were generally deeply (51%) or moderately (21%) sedated, and 81% of patients were delirious at any point during their ICU stay.

Of the 32 eligible patients, 9 (28%) died while in the MICU and 23 (72%) were referred for rehabilitation services with 16 (50%) and 20 (63%) patients receiving orders for PT and OT services, respectively (Fig. 1). The median (IQR) time from ICU admission to initial ICU evaluation by PT and/or OT was 10 (7-12) days. One patient died on the ward, leaving a total of 18 survivors at hospital discharge. Survivors had a median (IQR) ICU length of stay of 11 (7-13) days. These patients received rehabilitation treatments during a median (IQR) of 12% (0%-25%) ICU days per patient, of a potential 357 daily rehabilitation treatments in the ICU. Observed barriers to rehabilitation therapy included (1) ineligibility for therapy for a median (IQR) of 27% (15%-61%) of ICU days per patient, primarily due to patient sedation/nonresponsiveness, and (2) therapy not provided for a median (IQR) of 56% (25%-68%) of ICU days per patient, primarily due to a lack of rehabilitation staff. Patients

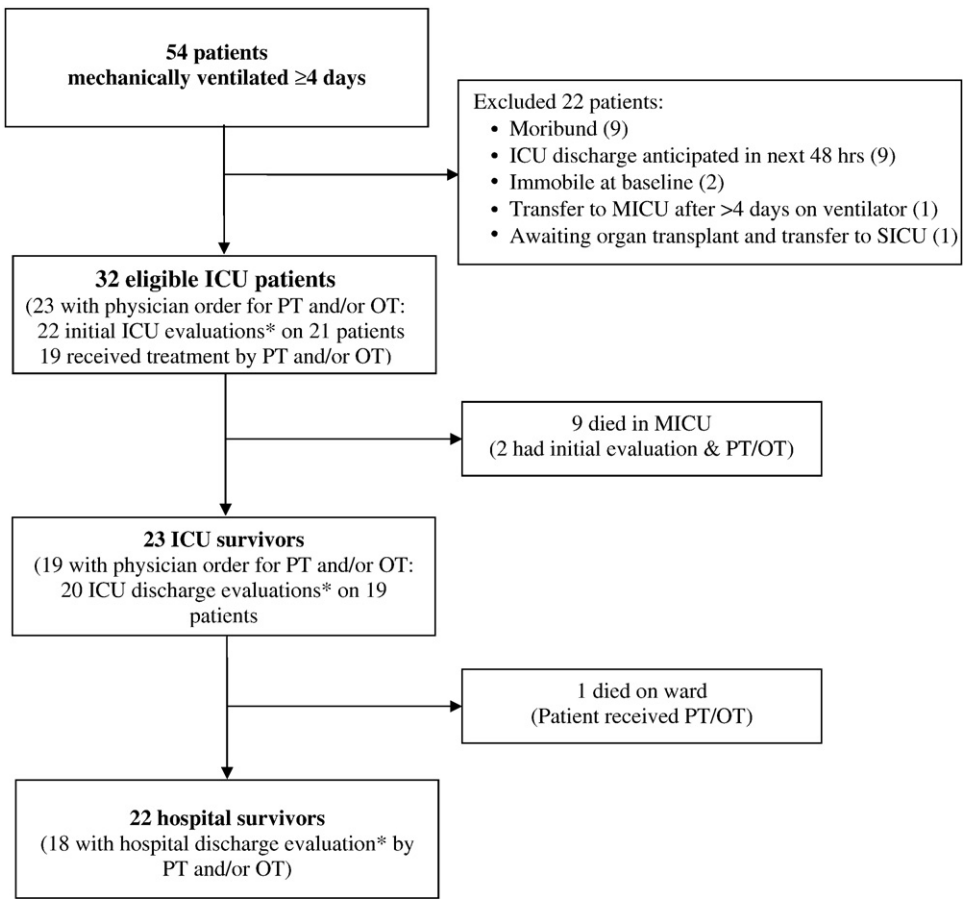

Fig. 1 Flow diagram of patients in rehabilitation project. *This number includes both complete and partial evaluations on eligible patients including 1 patient readmitted to MICU. Not all aspects of each evaluation (eg, ROM, MMT, and FIM) could be completed for each patient due to the lack of PT or OT consultation by physicians or due to patients' inability to fully participate.

Table 1 Patient characteristics

Characteristics	All patients (n = 32)
Demographics	
Age (y), median (IQR)	49 (42-57)
Female, no. (%)	20 (63)
Race, no. (%)	
White	15 (47)
African American	17 (53)
Comorbid disease, no. (%)	
Respiratory disease	14 (44)
Diabetes mellitus	9 (28)
Coronary artery disease	5 (16)
Arthritis	5 (16)
Stroke	3 (9)
MICU data	
Admission diagnosis, no. (%)	
Respiratory (including pneumonia)	22 (69)
Gastrointestinal	4 (13)
Cardiovascular	2 (6)
Nonpulmonary sepsis	1 (3)
Other	3 (9)
APACHE II score, median (IQR)	27 (21-30)
Ever delirious in ICU, no. (%)	26 (81)
Corticosteroids in ICU	
Ever receive medication, no. (%)	23 (72)
Duration of use (d), median (IQR)	6 (4-8)
Daily prednisone–equivalent dose (mg), median (IQR)	50 (30-60)

received a median (IQR) of 2 (1-4) treatments during their entire ICU stay, with each treatment having a median (IQR) duration of 45 (34-47) minutes. The most and least common rehabilitation activities were rolling (94%) and ambulation

Table 2 Frequency and description of rehabilitation treatments in the ICU

Rehabilitation activities	All treatments (n = 50) [a]
Total number of PT and OT treatments per patient in ICU, median (IQR)	2 (1-4)
Duration of each treatment (min), median (IQR)	45 (34-47)
Mobilization and functional activities during treatments, no. (%)	
Grooming	24 (48)
Bathing	23 (46)
Rolling	47 (94)
Sitting at the edge of the bed	27 (54)
Transfer from sit to stand	12 (24)
Ambulation	2 (4)
Artificial airways and femoral catheters during treatment, no. (%)	
Endotracheal tube	12 (24)
Femoral catheter	2 (4)

[a] These treatments occurred in 19 ICU patients who received a physician order for PT and/or OT.

Table 3 Physiologic responses during rehabilitation therapy

Physiologic responses	All treatments (n = 50) [a]
Change in heart rate (beats/min), median (IQR)	
Baseline to maximum (sustained for 1 min) during therapy	6 (2-10)
Baseline to end of therapy	1 (−2 to 4)
Change in blood pressure (mm Hg), median (IQR)	
Systolic: baseline to end of therapy	3 (−4 to 13)
Diastolic: baseline to end of therapy	2 (−4 to 8)
Change in percent oxygen saturation, median (IQR)	
Baseline to lowest during therapy	−1 (−2 to 0)
Baseline to end of therapy	0 (−1 to 1)

[a] These responses were recorded on 19 ICU patients who received PT and/or OT.

(4%), with 24% of activities occurring with an endotracheal tube in place (Table 2). Physiologic changes in heart rate, blood pressure, and oxygen saturation during treatment sessions were minimal (Table 3), with no unexpected events occurring during therapy.

Based on 14 to 18 patients assessments at each of the 3 assessment periods, ROM limitations occurred predominantly in the lower extremities and persisted throughout hospitalization. The most common ROM limitations involved ankle dorsiflexion (frequency 45%-56% across the 3 assessment periods), hip flexion (35%-39%), and hip extension (23%-31%). These deficits were severe with a median (IQR) lower extremity contracture index score of 38% to 45% across all 3 assessments (ie, 55%-62% relative decrease in joint ROM). Strength deficits were also more prevalent and severe in the lower extremities, but both upper and lower extremity muscle groups showed improvements in strength at each progressive assessment interval (Table 4).

Compared with self-reported functional status before hospital admission, patients demonstrated a significant decline in their ability to perform grooming, bathing, and functional mobility at the initial ICU assessment. By ICU discharge, only 6 of 16 ICU survivors were ambulatory. Although improvement in functional status was noted at the 2 successive assessments, functional tasks including rolling, supine to sit, ambulation, and the cumulative FSS-ICU were significantly decreased from prehospital baseline at hospital discharge (Table 5). All 22 surviving patients were living at home before hospital admission, but at discharge, 12 (55%) required inpatient rehabilitation due to their physical impairments.

4. Discussion

This pilot project was helpful in understanding barriers and safety issues related to rehabilitation therapy in mechanically ventilated patients in our traditional ICU and

Table 4 Rehabilitation outcomes during hospitalization

Outcome	Initial ICU assessment	ICU discharge	Hospital discharge
Lower extremity ROM [a]			
No. of patient assessments [b]	17	18	14
No. (%) of patient assessments with limited range	11 (65)	12 (67)	9 (64)
No. of joint assessments	220	236	190
No. (%) of joints with limited range	53 (24)	48 (20)	43 (23)
Contracture index score for limited joints, median (IQR) [c]	45% (38%-51%)	42% (39%-53%)	38% (34%-60%)
MMT			
Upper extremity			
No. of assessments [b]	17	17	16
Score (range: 0-50), median (IQR)	36 (26-40)	45 (38-50)	49 (40-50)
No. (%) of assessments <80% of maximum score	9 (53)	6 (35)	3 (19)
Lower extremity			
No. of assessments [b]	14	16	14
Score (range: 0-70), median (IQR)	32 (28-42)	42 (28-56)	56 (30-63)
No. (%) of assessments <80% of maximum score	11 (79)	12 (75)	6 (43)

[a] For upper extremity, only 2 (1%) of 191 of joints examined (both shoulder flexion) were limited at each assessment. For lower extremity, the joints most commonly limited were ankle dorsiflexion (45%-56% of assessments across the 3 assessments), hip flexion (35%-39%), and hip extension (23%-31%).

[b] The number of assessments varies across time points and between outcomes evaluated due to ICU readmission with repeat patient assessments, lack of consultation to OT and/or PT for all patients, and patients' inability to participate in complete assessment.

[c] A contracture index for each limited joint was obtained by dividing the joint's measured ROM by its maximal ROM. A contracture index score was then calculated for each patient as the mean of all contracture index values.

providing insight into measurement of ROM, muscle strength, and physical function in this patient population. Measuring ROM of numerous joints was time-consuming, and although deficits were present, there was little change over time. To enhance feasibility of assessment of ROM, it may be beneficial to focus on the lower extremity where most ROM impairments were found and to evaluate infrequently during the ICU and hospital stay. In assessing muscle strength, it was difficult to measure all proposed muscle groups due to constraints with patient positioning in the ICU setting. To minimize the effects of missing data, it may be more feasible to select a smaller number of muscle groups, which have easily tolerated positioning requirements in the ICU patient population. Finally, although there is a lack of validated measures of physical function in the ICU setting, we identified certain measures that seem relevant and able to measure change throughout the recovery process. Further work is needed in validating ICU-specific measures of physical function.

Based on data from 19 acute respiratory failure patients who received rehabilitation in the ICU, improvements in muscle strength and functional status occurred during hospitalization; however, major limitations in lower extremity joint ROM were common and did not improve in this small patient cohort. At hospital discharge, these patients frequently remained weak with an overall functional status that was significantly lower than it was before admission, frequently necessitating discharge to a rehabilitation facility.

In our traditional ICU, without an early mobility program, there are clearly many important barriers to rehabilitation. Once-daily therapy occurred on only 14% of ICU days. Although high severity of illness, including cardiovascular and pulmonary instability, may not be a modifiable barrier, there may be other means of increasing rehabilitation therapy for the time periods in which patients are medically stable. Moderate to deep sedation and a high frequency of delirium in those patients who were not heavily sedated may be modifiable through efforts to decrease oversedation [16,36,37]. Sedation is an especially important issue because sedative use, even when intermittent, has been associated with a 2-fold decrease in the likelihood of ambulation in patients with acute respiratory failure [38]. Most ICU's environments and culture contribute to patient immobility and related neuromuscular complications [36,38]. In our ICU, limited rehabilitation staffing and to a much lesser extent, lack of physician referral, also represented important barriers to therapy.

Few clinically significant physiologic changes were noted during rehabilitation treatments. This finding may be due, in part, to the small number of treatments that incorporated standing or ambulation. Moreover, among the treatments performed, an endotracheal tube or femoral line was present during 24% and 4%, respectively, with no unexpected events observed, consistent with prior literature from ICUs with an early mobility program [15,17].

Due to our exclusion criteria, a large majority of eligible patients were independent with grooming, bathing, and functional mobility before admission; thus, the marked decline in functional status, strength and joint mobility likely can be attributed to their critical illness and ICU care. In

Table 5 Physical functional status for all patient assessments

	Median (IQR) score			
	Baseline before hospital admission [a]	Initial ICU assessment	ICU discharge	Hospital discharge
Activities of daily living (range, 0-7) [b]				
No. of assessments [c]	18	20	18	15
Grooming	7 (7-7)	3 (1-4)	4 (3-5)	5 (4-7)
Bathing	7 (5-7)	3 (1-4)	4 (3-4)	4 (3-7)
Functional mobility (range, 0-7) [b]				
No. of assessments [c]	18	20	19	18
Rolling	7 (6-7)	2 (2-3)	4 (2-6)	5 (3-7) [d]
Supine to sit	7 (6-7)	2 (2-3)	3 (2-6)	4 (3-7) [d]
Sitting at the edge of the bed	7 (6-7)	4 (2-5)	5 (4-6)	7 (5-7)
Transfer from sit to stand	7 (6-7)	1 (0-3)	2 (1-5)	4 (2-7)
Ambulation	7 (6-7)	0 (0-0)	0 (0-1)	1 (0-6) [d]
Cumulative FSS-ICU (range, 0-35)	35 (31-35)	10 (5-13)	14 (10-23)	20 (13-34) [d]
Activity level				
Sitting at edge of bed				
No. of assessments [c]	18	22	19	18
No. (%) of sitting activities with unlimited duration	14 (78)	4 (18)	9 (47)	12 (67)
Sitting with limited duration (min), median (IQR) [e]	0 (0-5)	6 (1-15)	7 (5-12)	13 (7-15)
Ambulation				
No. of assessments [c]	18	17	16	16
No. (%) of ambulation with unlimited distance	13 (72)	0 (0)	1 (6)	3 (19)
Ambulation with limited distance (ft), median (IQR) [d]	0 (0-300)	0 (0-0)	0 (0-11)	2 (0-200)

[a] Retrospective assessment based on standardized interview with the patient (n = 1) or proxy (n = 17).

[b] Evaluated using the following scoring system: 0 = unable to perform, 1 = total assist (subject 0%+), 2 = maximum assist (subject 25%+), 3 = moderate assist (subject 50%+), 4 = minimal assist (subject 75%+), 5 = supervision, 6 = modified independence (requires assistive device), and 7 = complete independence.

[c] The number of assessments varies across time points and between outcomes evaluated due to ICU readmission with repeat patient assessment, lack of consultation to OT and/or PT for all patients, and patients' inability to participate in complete assessment.

[d] $P < .05$ compared with baseline before hospital admission using Wilcoxon rank-sum test.

[e] For those unable to perform assessments, 0 minute and 0 feet were assigned, respectively, for sitting with limited duration and ambulation with limited distance.

patients with an ICU stay more than 2 weeks, joint ROM limitations are common and persistent and contribute to impaired physical function [39]. Similar to this prior study [39], we observed that ROM limitations were common with ankle dorsiflexion and hip flexion and extension, but in contrast, did not find frequent limitations in elbow and knee joints. Clinically significant muscle weakness was prevalent at the ICU initial assessment, and its prevalence seems higher than in prior literature [30,31], perhaps due to differences in patient populations. Our patients did show improvement in strength over time, as observed in prior literature [30], but clinically important weakness was still common at hospital discharge, occurring in 19% and 43% of upper and lower extremity evaluations, respectively.

One ICU with an intensive early mobility program reported that 78% of survivors ambulated by ICU discharge [15]. In contrast, only 6 (37%) of 16 ICU survivors ambulated by ICU discharge. The lack of an early mobility program and our ICU culture in which patients were frequently sedated without an emphasis on early rehabilitation likely contributed to these lower ambulation rates [36].

There are several potential limitations with our report. First, our sample size was small and taken from a single medical ICU, which may limit the precision and generalizability of these results. Second, due to the observational design of this report, we cannot assess the causal effect of rehabilitation on patient outcomes. Third, although it was possible to establish the patient's prehospital baseline functional status by using a retrospective interview, we were unable to assess if ROM limitations seen on initial ICU evaluation were present before hospitalization. Finally, there are no methods for assessing muscle strength and functional status that have been specifically validated in ICU patients. The validated FIM does not evaluate basic mobility skills (eg, rolling), which are more relevant for weak ICU patients [11]. Until further validation work is done, this limitation is common to all publications in this field and was addressed through using methods similar to prior ICU publications [29-31,34,35,40].

In summary, this report presents findings regarding routine rehabilitation therapy in a traditional MICU without an intensive early mobility program. While rehabilitation therapy appeared safe without significant physiologic

changes or adverse effects, patients infrequently received rehabilitation therapy during their ICU stay. Potentially modifiable barriers to rehabilitation included deep sedation, inadequate rehabilitation staffing, and lack of physician orders for therapy. Major deficits in joint ROM and muscle strength were particularly common in the lower extremities contributing to ICU-acquired impairment in patients' functional status that persisted during hospitalization and contributed to patients requiring inpatient rehabilitation after hospital discharge. Future studies need to evaluate methods of reducing barriers to rehabilitation therapy and to further investigate the effects of rehabilitation on patients' short- and long-term functional outcomes and quality of life.

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