Critical Care Explorations

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The Effects of Early Mobilization on Patients Requiring Extended Mechanical Ventilation Across Multiple ICUs

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Objectives: 1) To successfully implement early mobilization of individuals with prolonged mechanical ventilation in multiple ICUs at a tertiary care hospital and 2) to reduce length of stay and improve quality of care to individuals in the ICUs.

Design: Comparative effectiveness cohort study based on a quality improvement project.

Setting: Five ICUs at a tertiary care hospital.

Patients: A total of 541 mechanically ventilated patients over a 2-year period (2014–2015): 280 and 261, respectively. Age ranged from 19 to 94 years (mean, 63.84; SD, 14.96).

Interventions: A hospital-based initiative spurred development of a multidisciplinary team, tasked with establishing early mobilization in ICUs.

Measurements and Main Results: Early mobilization in the ICUs was evaluated by the number of physical therapy consults, length of stay, individual treatment sessions utilizing functional outcomes, and follow-up visits. Implementation of an early mobilization protocol across all ICUs led to a significant increase in the number of physical therapy consults, a significant decrease in ICU and overall lengths of stay, significantly shorter days to implement physical therapy, and a significantly higher physical therapy follow-up rate.

Conclusions: Mobilizing individuals in an intensive care setting decreases length of stay and hospital costs. With an interdisciplinary team to plan, implement, and evaluate stages of the program, a successful early mobilization program can be implemented across all ICUs simultaneously and affect change in patients who will require prolonged mechanical ventilation.

Key Words: intensive care unit; mechanical ventilation; mobilization; quality improvement; rehabilitation

Immobilization may lead to lasting physical, cognitive, and psychologic impairments (1). One-year outcomes in survivors of acute respiratory distress syndrome, who required a stay in an ICU, show persistent muscle wasting and joint weakness 12 months after hospital discharge (2). Half of these same patients had not returned to work 1 year after hospital discharge (2).

Healthy individuals on bed rest lose 5% muscle mass in 1 week (3, 4), whereas those on bed rest with multiple organ failure lose 16% muscle mass seen in 1 week (5). Prolonged stay in an ICU has been associated with the development of neuromuscular dysfunction, including polyneuropathy and myopathy, in up to 46% of patients (6). The term "ICU-acquired weakness" is used to encompass both critical illness polyneuropathy and critical illness myopathy because these diagnoses occur with overlapping pathophysiology and clinical presentations.

A study on over 200 acute respiratory distress syndrome survivors showed impaired function and strength, and that the only predictors of decrease in strength were age and duration of bed rest (4). Severity of illness did not affect strength. Bed rest was the only modifiable risk factor. Given loss of muscle mass in patients on bed rest with multiple organ failure, early intervention is crucial (7). Persons who develop ICU-acquired weakness have been shown to have significantly lower strength, quality of life, and function for as long as 2 years after discharge (4). Previous studies have shown that 84–95% of persons who develop ICU-acquired weakness have impaired mobility and quality of life that persists for up to 5 years (8) and increased mortality (9, 10).

Early mobilization, within the first few days of admission to a medical ICU, decreases length of stay and mortality while improving outcomes, functionality, and self-care at discharge (11–16). Benefits of early mobilization for these patients also include decreased readmissions, increased strength, increased independence, and cost savings (13, 15–18). In previous early mobilization

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projects, barriers to implementation have included availability of staff, equipment, over sedation, and lack of education regarding feasibility and safety of early mobilization. Overcoming these barriers is important to a successful early mobilization program (11, 16, 19–21).

Previous early mobilization programs have been successfully installed in medical ICUs (11, 13, 22) and to a lesser degree in cardiovascular ICUs (23) and a surgical ICU (24). Up to this point, we are aware of no published reports of successful implementation of an early mobilization program in more than one ICU concurrently or of published reports focused on patients requiring prolonged mechanical ventilation.

MATERIALS AND METHODS

Participants

Patients included 541 critically ill and mechanically ventilated patients over a 2-year period (2014–2015): 280 and 261, respectively. Age ranged from 19 to 94 years (mean, 63.84; SD, 14.96). Further demographic data can be found in **Table 1**. Additional inclusion/exclusion information is provided within the detailed protocol description below.

Respiratory Recovery Pathway

The study was conducted at a 1,171-bed tertiary care hospital in New York City. In 2015, there were 1,296 admissions to the ICUs that required mechanical ventilation. The hospital had a total of five ICU (69) beds, including surgical, neurosurgical, cardiac, cardiothoracic, and medical ICUs.

In fall of 2014, a hospital initiative focused on improved care for critically ill and mechanically ventilated patients. The emphasis was improved outcomes, quality of care, and early mobilization to be initiated across five ICUs simultaneously. This initiative became known as the "respiratory recovery pathway." The respiratory recovery pathway was established as a multidisciplinary committee consisting of administration, critical care medicine, anesthesia, gastroenterology, otolaryngology, palliative care, physiatry, rehabilitation, nursing, social work, and case management.

The initiative focused on patients in diagnostic-related group code levels 3 and 4. As per the centers for Medicare and Medicaid services, diagnostic-related group 3 refers to patients requiring extracorporeal membrane oxygenation or mechanical ventilation greater than 96 hours that also required a major operating room procedure, whereas diagnostic-related group 4 refers to patients requiring tracheostomy placement with mechanical ventilation of greater than 96 hours that did not require a major operating room procedure. Diagnostic-related group 3 and 4 coding encompass a set of critically ill patients who will require prolonged mechanical ventilation plus or minus the need for tracheostomy. By definition, this group of patients has sustained respiratory failure and requires significant resources. We chose to use this designation as a proxy to a severity of illness score, given that these groups are often used for billing and coding purposes and thereby could be of particular interest to hospital administrations. Of note, all patients in the ICUs were offered early mobilization, but we only present data for those patients who ultimately were designated as diagnosis-related group 3 or 4.

For the five ICUs targeted, 63% of those patients in diagnostic-related group codes 3 and 4 had excess lengths of stay, relative to expected based on the premier healthcare database, an online national healthcare database, totaling 5,995 excess days in 2014. Although the respiratory recovery pathway has many parts, special emphasis was placed on early mobilization because it has shown to be safe, feasible, and improve outcomes for patients (12, 13, 16, 25).

A respiratory recovery pathway mobility committee was established to formalize a plan to provide rehabilitation services, improve quality care, and decrease lengths of stay for patients in diagnostic-related groups 3 and 4 across all five ICUs. Emphasis was placed on overcoming well-known barriers to early mobilization (e.g., staffing, equipment, sedation) and establishing a detailed mobility protocol before initiation of the early mobilization in January of 2015.

Using a previously successful early mobilization program, staffing and equipment needs were estimated and a budget proposal was created (25). Given the published literature showing that investing in ICU early mobilization shortens lengths of stay and provides significant cost savings (12, 15–17), the hospital system chose to invest in the staffing and equipment needs for early mobilization in the respiratory recovery pathway. A dedicated team was created to accommodate the proposed increase in number of patients to be seen by therapies in the ICUs. Based on an estimated length of stay reduction of 19–20% (17), the final budget included funding for 1.7 full-time equivalents of physical therapy, 1 full-time equivalent of occupational therapy, 1.5 full-time equivalents of respiratory therapy, and 1.6 full-time equivalents of physical therapy aide. Total salaries, fringe benefits, and equipment costs were approximately $604,000. The estimated 20% reduction in lengths of stay for the patients with diagnostic-related group 3 and 4 would cover the costs of this investment while improving care delivery.

A known barrier to implementation of early mobilization in the ICU was oversedation (20, 26, 27). Emphasis in the respiratory recovery pathway was placed on daily sedation breaks that were coordinated with therapy sessions. An as needed sedation protocol was developed to discourage the use of continuous sedation; however, every unit was allowed to continue managing sedation as medically necessary.

Education of ancillary staff, nursing, physicians, and therapists on the safety, feasibility, and benefits of early mobilization (15, 16, 22, 23, 27, 28) helped implement an early mobilization protocol in the ICUs and allow nursing to feel ownership of the process.

Development of Protocols and Contraindications for Therapy

With a committee and team in place, a protocol for mobilizing patients was still needed. The Mount Sinai mobility protocol for critically ill patients was developed as a concerted effort by physiatrists, critical care physicians, nurses, and therapists. Given the variety in diagnoses encountered in the respiratory recovery pathway program, clear exclusion criteria for different levels of mobilization were adapted from previous successful programs and from expert consensus (11, 29). Utilizing a graded approach to advancing mobilization, the Mount Sinai mobility protocol for critically ill patients

TABLE 1. Demographics

Demographics	2014, *n* (%)	2015, *n* (%)	Total, *n* (%)
Marital status			
Single	79 (28.2)	78 (29.9)	157 (29)
Married/life partner	126 (45)	113 (43.3)	239 (44.2)
Divorced/separated	25 (8.9)	26 (10)	51 (9.4)
Widowed	29 (10.4)	25 (9.6)	54 (10)
Unknown	21 (7.5)	19 (7.3)	40 (7.4)
Total	280 (100)	261 (100)	541 (100)
Race			
Black/African American	45 (16.1)	56 (21.5)	101 (18.7)
Asian	15 (5.4)	8 (3.1)	23 (4.3)
White	131 (46.8)	96 (36.8)	227 (42)
Other	58 (20.7)	65 (24.9)	123 (22.7)
Unknown	31 (11.1)	36 (13.8)	67 (12.4)
Total	280 (100)	261 (100)	541 (100)
Sex			
Female	116 (41.4)	112 (42.9)	228 (42.1)
Male	164 (58.6)	149 (57.1)	313 (57.9)
Total	280 (100)	261 (100)	541 (100)

All 541 patients are represented in this table and presented using within-group counts and percentages of patients split between the 2 study years: 2014 and 2015. Percentages are presented in parentheses. Unknown refers to information not being available, whereas other refers to a self-identification choice made by a patient. It should be noted that age ranged from 19 to 94 years (mean, 63.84; SD, 14.96). Basic demographics can be seen along the left hand of the table and focused on marital status, race and sex. Demographics are broken up between 2014 (the year prior to implementation of early mobilization) and 2015 (the year of implementation of early mobilization). There were no statistically significant differences between the two study years.

allows patients to progress in their rehabilitation while closely monitoring their medical status and activity tolerance (**Fig. 1**).

The mobility protocol relies on all care team members, including physicians, nurses, and therapists. Upon admission to an ICU, unless a contraindication existed, the mobility protocol was initiated. The goal was to initiate level 1 mobilization as early as possible and advance to at least level 2 by 72 hours. The graduated approach to advancement in mobility began with level 1 and progressed to level 4. Earlier levels were generally nursing led, and once a patient was able to tolerate head of bed elevation past 65° and/or able to sit at the edge of the bed, physical therapists were consulted to progress to higher-level mobilization.

The Mount Sinai mobility protocol is meant to be a guide. If a patient has special considerations, such as a positive end-expiratory pressure over 10, the care team may allow an exception to progress this patient onto level 3 or 4. **Table 2** shows the absolute contraindications to progression in mobilization (29). Patients who demonstrate clinical signs outside these contraindications are discussed and may be advanced in mobility level if deemed appropriate. Patients are advanced based on tolerance, such that if a patient's vitals negatively changed within one level, the next was not attempted. Patients had continuous monitoring of vitals during all therapy sessions, and a respiratory therapist was on hand. After implementation, in 2015, there were two events qualifying as major adverse events: one central line was dislodged and another patient had a controlled fall while undergoing a transfer via a mechanical lift.

Outcome Measures

Following assessment of barriers and development of the Mount Sinai mobility protocol, planned outcome measures were established for the respiratory recovery pathway early mobilization project. These measures included: number of physical therapy consultations, follow-up visits and functional tasks performed during these sessions, and average length of stay for diagnostic-related group 3 and 4 coded patients (11, 19). Functional goals were tracked by following the number of therapy sessions that included sitting at the edge of the bed, standing, and ambulating.

Statistical Methods

Descriptive statistics were calculated for number of consults, lengths of stay, age, excess days, days to physical therapy, and follow-up visits. Independent samples *t* tests were used to determine statistically significant differences between the years immediately before and after program implementation (2014 and 2015), with planned adjustment for heterogeneity of variances as determined by Levene test. Statistical significance was set at α equals to 0.05 for all analyses. Programs used for data analyses and graph generation include IBM SPSS Statistics Version 23 (IBM Corp., Armonk, NY) and Microsoft Office Excel 2016 (Microsoft Corp., Redmond, WA). The study was reviewed by the Institutional Review Board and deemed to meet exempt status.

RESULTS

Quality Improvement in the ICU

The respiratory recovery pathway early mobilization program focused on improving the overall quality of care given to patients in diagnostic-related groups 3 and 4 across five ICUs simultaneously and officially began on January 1, 2015. As noted previously, these patients by definition had a high severity of illness and were of particular interest at the study site because they typically had a large number of excess days above those expected based on the premier healthcare database.

Unless otherwise stated, results presented refer to patients in diagnosis-related groups 3 and 4. Compared with the previous year, the 2015 inception of the early mobilization program in the ICUs showed a statistically significant decrease in ICU length of stay ($t[538] = 2.01$; $p < 0.05$); overall hospital length of stay ($t[535.16] = 3.30$; $p < 0.002$); excess days ($t[534.93] = 3.54$; $p < 0.001$); days until initiation of physical therapy ($t[374] = 3.91$; $p < 0.001$); and an increase in physical therapy follow-up ($t[270.67] = -2.11$; $p < 0.05$) (**Table 3**).

As an exploratory research question, we examined functional data to further appreciate that the quality of early mobilization provided by the respiratory recovery pathway was a significant contributor to our outcomes. **Table 4** provides a quality check of

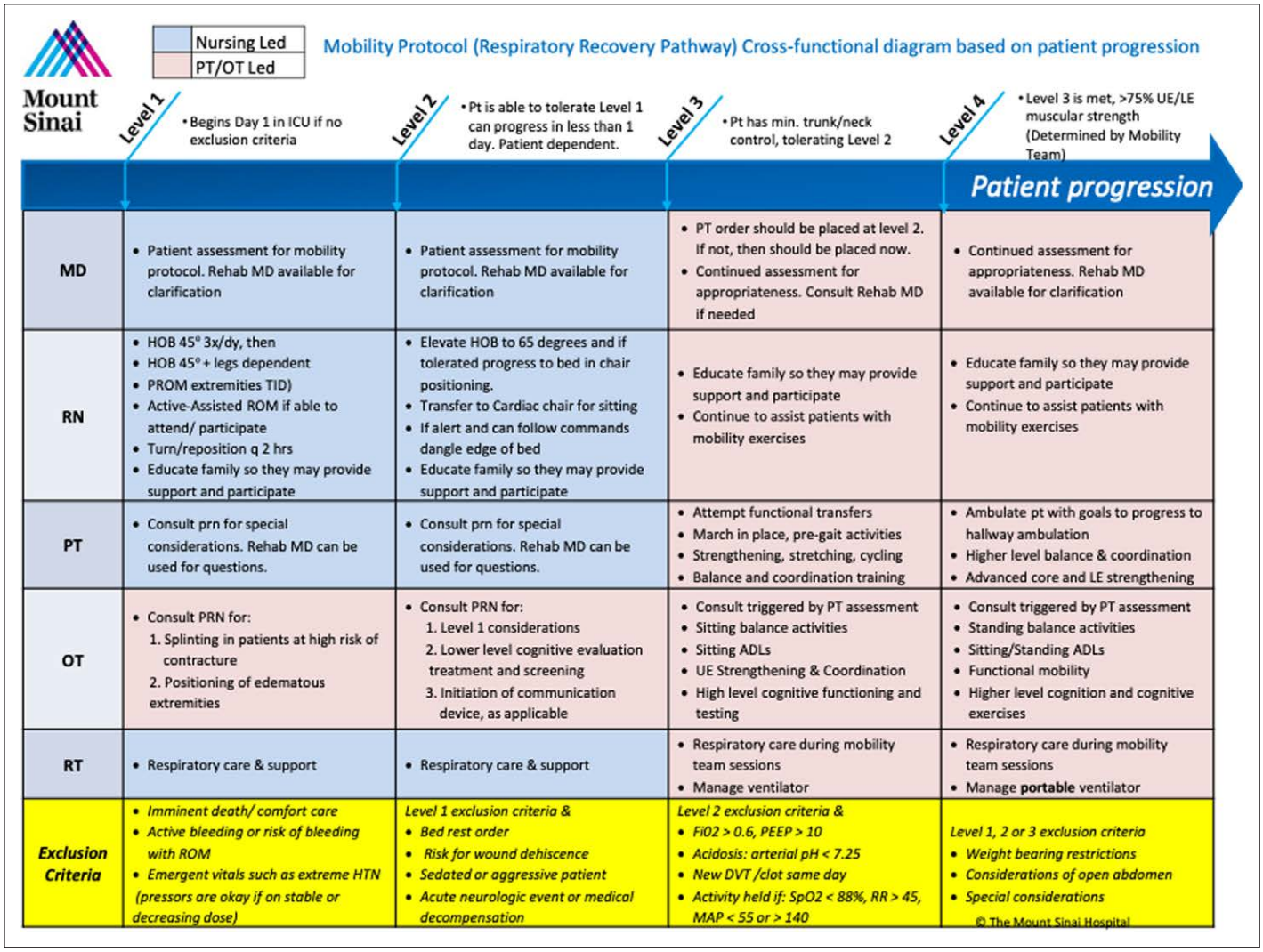

Figure 1. Mount Sinai mobility protocol: includes levels of mobility with definitions thereof and the roles of every team member and exclusion criteria.

our own functional data on patients in diagnostic-related groups 3 and 4 during a 6-week period near the end of 2015. The data include the activity level for a patient in a given session. In 282 unique treatment sessions from October 25, 2015, to December 4, 2015, patients sat at the edge of the bed or dangled. To further delineate between patients using mobility levels, those patients considered either mobility level 3 or 4 (medium or high level) were separated. The purpose of collecting these data and making the distinction between levels was to ensure that those patients on the early mobilization programs were achieving functional goals in therapy sessions appropriate for their mobility levels (e.g., 96.8% of those patients who were considered mobility level 3 or 4 were dangled).

The average length of stay and number of excess days per unit for diagnostic-related group 3 and 4 can be strongly affected by the overall number of admissions with excess days. Excess days refer to the number of days over the expected length of stay as per the premier healthcare database. Excess days are at risk of not being reimbursed by insurance companies and as such are an important metric. It should be noted that of the 540 patients, some had multiple admissions resulting in a total of 628 admissions. In 201, there were 309 admissions totaling 5,955 excess days, or 19.4 excess days per admission. In 2015, there were 319 admissions and 2,865 excess days, or 9 excess days per admission. In total, there were 3,090 less excess days in 2015 compared with 2014.

DISCUSSION

Coordination between five ICUs required strong support from hospital administration. Early mobilization is crucial for long-term physical and psychosocial outcomes and could improve length of stay and decrease excess days in patients who due to medical acuity will require prolonged mechanical ventilation (4, 6, 7, 12, 15, 16).

Patients designated to diagnostic-related group 3 or 4 require prolonged mechanical ventilation. This subset of patients is of particular interest to hospitals because they are at increased risk of excess lengths of stay. Although patients designated within a diagnostic-related group 3 or 4 are particularly ill, they are emphasized in this project to show that even those patients who have prolonged hospital courses can achieve shortened lengths of stay from coordinated

TABLE 2. Contraindications and Precautions to Therapy in the ICU

Contraindications to Any Mobilization	Contraindications to Out-of-Bed Mobilization
• Requiring IV antihypertensive for hypertensive emergency	• Oxygen saturation < 90
- Bradycardia requiring pharmacologic treatment (e.g., isoprenaline)	• Ventilatory mode in high-frequency oscillatory ventilation
- Bradycardia awaiting emergent pacemaker	• Mean arterial pressure below target and causing symptoms
- Prone positioning	• Mean arterial pressure below target despite support (vasoactive or mechanical)
- Richmond Agitation Sedation Scale > +2	• Transvenous or epicardial pacemaker–dependent rhythms
- Active management of intracranial hypertension with intracranial pressure not in desired range	• Ventricular rate > 150
- Spinal precautions before clearance or fixation	• Femoral intra-aortic balloon pump
- Uncontrolled seizures	• Extracorporeal membrane oxygenation with femoral or subclavian (NOT single bicaval dual-lumen cannulae)
- Uncontrolled active bleeding	• Cardiac ischemia
- Comfort care/impending death	• Richmond Agitation Sedation Scale < −2
	• Open lumbar drain (not clamped)
	• Unstable major fracture (pelvic, spinal, lower limb long bone)
	• Large open surgical wound (chest/abdomen)
	• Femoral sheaths

The entirety of this table is taken from Hodgson et al (29). It reflects the portion of all the contraindications and precautions to therapy in the ICU presented in their work that were used in the respiratory recovery pathway.

TABLE 3. Mean Changes in Outcomes Postinitiation of the Respiratory Recovery Pathway and Early Mobilization Protocol Simultaneously Across Five ICUs Between 2014 and 2015

Outcome Variable	2014, Mean (SD)	2015, Mean (SD)
ICU length of stay (d)[a]	34.40 (21.87)	30.57 (22.4)
Overall length of stay (d)[a]	52.70 (35.48)	43.30 (30.61)
Excess days[a]	16.51 (35.22)	6.47 (30.6)
Days to physical therapy from admission to the ICU[a]	20.09 (14.06)	14.78 (12.12)
No. of physical therapy follow-up consults[b]	6.14 (5.21)	7.73 (7.93)

[a]Decrease indicates a favorable outcome.
[b]Increase indicates a favorable outcome.

TABLE 4. Summary of 6 Weeks (October 25, 2015, to December 5, 2015) of Functional Milestones

Type of Treatments	Dangle	Stand	Transfer to Chair	Ambulation
No. of treatments administered	176	85	37	37
All level ICU patients (%)	66.2	32.0	13.9	13.9
Medium- and high-level ICU patients (%)	96.8	77.4	51.6	51.6

In total, 46 patients in diagnostically related groups 3 and 4 admitted to five ICUs participated in 282 unique sessions of early mobilization. Of note given that functional milestone is along a progression, more than one could be achieved within a single session. For example, all patients who ambulated by definition also transferred to chair, stood, and dangled.

efforts such as the respiratory recovery pathway. Although data presented focused on those patients within these diagnostic groups, equal early mobilization was given to all appropriate intensive care patients with a strong belief that early mobilization is essential. All patients ultimately falling into diagnostic-related groups 3 or 4 received early mobilization as soon as deemed medically appropriate based on safety criteria. In many cases, physical therapy was started before a patient's diagnostic-related group designation.

Given the incremental increase of physical therapy consults and only the 1.7 full-time equivalent increase of physical therapists provided to the respiratory recovery pathway, additional physical therapy staffing was drawn from other areas of the hospital for a total of 2.7 full-time effort physical therapists. Although the number of consults alone is not a measure of success, it does represent an improved cultural acceptance of ICU early mobilization.

Decreased length of stay and decreased excess days seen were not only of significant cost savings to the hospital system, but also allowed for more efficient turnover of beds. Thus, by delivering a higher quality of care, reducing overall average length of stay, and cutting excess days in half, we were able to deliver higher quality of care to a larger number of patients in need while also providing financial benefit to the system.

Few studies exist outside of the medical ICU setting showing that early mobilization decreases length of stay, improves outcomes, decreases mortality, and improves functionality (11–17). Our project shows that early mobilization is feasible and safe across all types of ICUs and that it can affect change even in a population of patients requiring prolonged mechanical ventilation.

Our future directions include targeted education and staffing and improved understanding of functional outcomes to be able to prognosticate functionality based on activities performed during early mobilization.

LIMITATIONS

Limitations of this project include not having access to accurate data on total ventilator days beyond 96 hours. In addition, patients were not followed once discharged from the hospital. Although we can be confident that we improved acute care for these patients, we cannot know that the benefits were lasting. Finally, the late addition of functional data should have been done prospectively and will be a future goal for our next study.

CONCLUSIONS

Changing of ICU culture through nursing ownership, alteration of sedation practices, and allocation of appropriate resources for early mobilization has been shown successful on single units at a time. We were able to demonstrate that with appropriate planning, the same positive changes in length of stay and quality delivery of early mobilization are possible on a large scale and across various patient populations. In addition, we were able to show change on a patient population that is of particular interest given their prolonged need for mechanical ventilation and high likelihood of excess days.

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