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Normal Baseline Function Is Associated With Delayed Rehabilitation in Critically Ill Children

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Abstract

Background: Early mobilization of patients in the adult intensive care unit (ICU) is associated with improved functional outcomes and shorter ICU stay. Although emerging evidence suggests that early mobilization in pediatric ICUs (PICUs) is safe and feasible, physical therapist (PT) consultation may be delayed because of perceptions that patient acuity precludes mobilization activities. Factors that influence timely involvement of PTs to facilitate acute rehabilitation in critically ill children have not been characterized. The aim of this study was to identify patient-level factors for early PT consultation in a tertiary care PICU before large-scale implementation of a multicomponent early mobilization program.

Methods: We conducted a retrospective analysis of data from the PICU Up! Quality Improvement Initiative. The primary outcome was early rehabilitation, defined as PT consultation within the first 3 days of PICU admission. Patients ($n = 100$) were divided into 2 groups by outcome, and predictive factors for early rehabilitation were analyzed with logistic regression.

Results: Of 100 children, 54% received early rehabilitation. In univariate analyses, higher pediatric risk of mortality (PRISM) score ($P < .001$), baseline motor impairment ($P < .01$), developmental delay ($P = .04$), mechanical ventilation ($P = .1$), and number of devices ($P = .01$) were associated with early rehabilitation. In a logistic regression model, predictive factors for early rehabilitation included baseline motor impairment (adjusted odds ratio 5.36, 95% confidence interval [CI] = 1.3–22.0) and higher PRISM score (adjusted odds ratio = 1.17, 95% CI = 1.02–1.34).

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Authors' Note

All authors provided concept/idea/research design, writing, and data analysis. Dr Shinya Miura provided data collection. Dr Sapna R. Kudchadkar provided project management, study participants, facilities/equipment, institutional liaisons, and consultation (including review of manuscript before submission).

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Conclusions: Critically ill children with normal baseline function or lower acuity of illness are less likely to have initiation of early rehabilitation with PT prior to implementation of a unit-wide early mobilization program. Baseline motor impairment and higher PRISM scores were independently associated with early rehabilitation. These findings highlight the need for streamlined criteria for PT consultation to meet the rehabilitation needs of all critically ill patients.

Keywords

early mobilization; pediatrics; critical care; program development; risk factor; child; postoperative complications; postoperative care

Introduction

Patients with critical illness often experience physical and psychological sequelae of their stay in the intensive care unit (ICU).^{1–3} Issues stemming from the ICU stay can affect survivors for years after discharge and inhibit them from returning to their normal lives.^{3,4} One of the sequelae of critical illness is ICU-acquired weakness (ICUAW). The polyneuropathy-and myopathy-induced muscle weakness characteristic of ICUAW results from multifactorial etiologies ranging from immobilization and deconditioning to systemic inflammation during ICU stay.^{5,6} Studies have shown that prolonged bed rest is also associated with ICUAW development.^{7,8} Unfortunately, patients who develop ICUAW often experience decreased quality of life and increased mortality.^{6,9,10}

Interest is growing in early rehabilitation for critically ill patients to improve their muscle strength and physical function. A strong foundation of evidence has shown that, with close involvement of physical therapists (PTs), early rehabilitation is feasible for adults in the ICU and associated with improved functional outcomes, decreased duration of mechanical ventilation, and shortened length of stay (LOS) in the ICU and hospital.^{11–18}

Recent literature has documented that many children also suffer from long-lasting physical disabilities after critical illness.^{19,20} In addition, evidence has shown that early mobilization is safe and feasible for critically ill children, including those with mechanical ventilation.^{18,21,22} However, most children in the pediatric ICU (PICU) are heavily sedated and immobilized because of a perceived need for rest and recovery.^{23,24} It is these children who may benefit most from early intervention by PTs and occupational therapists (OTs).^{18,21}

Previous studies in adults have reported that common barriers surrounding early mobilization include patient condition, safety concerns, personnel limitations, and institutional barriers.^{12,16,23–26} However, few studies have investigated factors that might influence timely initiation of acute rehabilitation in the PICU. Therefore, we conducted a study to identify predictive factors for timely initiation of early rehabilitation in the PICU.

Methods

Study Population

Patients were identified through an existing quality improvement (QI) database from the “PICU Up!” QI Study. Detailed methodology for this multidisciplinary QI intervention is

described elsewhere.²¹ PICU Up! was conducted with a pre-and postintervention methodology in children 1 day to 17 years old who were admitted to our institution's PICU from July to September of 2014 and 2015 and had an LOS of at least 3 days. The primary objective of that QI study and intervention was to increase the proportion of children with PT/OT consultation by PICU day 3, as well as to characterize safety and feasibility. In the current study, we reviewed 100 patients from the preintervention phase in 2014 and analyzed the data to characterize predictive factors for early rehabilitation before the implementation of an early mobilization program and unit-wide culture change.²¹

Setting

Our institution's PICU is a 40-bed academic, tertiary care, combined medical–surgical unit with single patient rooms. Care is provided for children 1 day to 21 years old. Registered nurse to patient ratios are 1:1 or 1:2 depending on patient acuity. Multidisciplinary care, including acute rehabilitation, is provided to admitted patients throughout the year. The consultation and treatments by pediatric PTs, OTs, and speech/language pathologists are available on the same day they are ordered by a medical provider if the order is placed on morning rounds. Both PT and OT consults are ordered simultaneously and both collaborate to determine which services are needed. The institutional review board (IRB) of the Johns Hopkins hospital comprehensively reviewed and acknowledged this QI project and determined that IRB approval was not required.

Data Collection and Definition of Variables

The primary outcome was early rehabilitation, which we defined as PT consultation being ordered by PICU day 3. All patients from the preintervention phase were divided into 2 groups: the early rehabilitation group and the delayed rehabilitation group. Factors that might influence the timing of PT consultation were identified based on adult literature and PICU practice and were collected through retrospective chart review. Baseline variables collected included demographics (age, sex, body weight), baseline conditions (motor impairment, developmental delay, neuromuscular disease, cardiac disease), admission category (medical or surgical admission), pediatric risk of mortality (PRISM) score,²⁷ and admission before a weekend (Thursday or Friday). Other variables included the highest level of respiratory support on PICU days 2 and 3 (mechanical ventilation via endotracheal tube/tracheostomy, continuous or bi-level positive airway pressure, heated high-flow nasal cannula [HHFNC], or oxygen therapy [face mask/nasal cannula]); the number of continuously used devices (arterial line, central venous line, peripheral venous line, Foley catheter, drains, intracranial pressure monitor); extracorporeal membrane oxygenation (ECMO); open chest; open abdomen; unstable fracture; Glasgow Coma Scale; State Behavioral Scale; the Face, Legs, Activity, Cry, Consolability Scale; and usage/dose of sedative-analgesics and neuromuscular blockade. Time-related variables were assessed at 0800 on PICU days 2 and 3, and the sum or average was used for analysis. The PICU LOS was reviewed as a patient outcome variable.

Statistical Analysis

Dosages of opioids and benzodiazepines were converted to morphine and midazolam equivalents, respectively. Potential predictive factors for early rehabilitation were analyzed

by univariate analyses (χ^2 test for categorical variables or t test for continuous variables). We included variables that were associated with early rehabilitation at $P < .10$ in the univariate analyses and clinically relevant variables (age, sex) in a logistic regression model to obtain the adjusted odds ratio and 95% confidence interval (CI), using a step-wise forward process. Two-tailed P values less than .05 were considered statistically significant. STATA 14 (StataCorp LLC, College Station, Texas) was used for all statistical analyses.

Results

Baseline characteristics for the study sample ($n = 100$) are shown in Table 1. The median age was 6.4 years (range: 1 month–17 years). Thirty-three (33%) patients were female, and medical and surgical diagnoses constituted 54% and 46%, respectively. The median PRISM score was 5 (range: 0–15), and the median PICU stay was 5 days (interquartile range [IQR]: 3.5–7.5).

Twenty-eight patients had baseline motor impairments and 32 had developmental delay. Eighteen patients presented with cardiac disease. The highest level of respiratory support during days 2 and 3 were mechanical ventilation support in 30 patients, noninvasive positive pressure ventilation in 10 patients, HHFNC in 10 patients, and simple face mask/nasal cannula in 21 patients. Midazolam was the primary benzodiazepine, whereas morphine, hydromorphone, and fentanyl were the opioids utilized. Four patients received continuous infusion of neuromuscular blockade. One patient was on ECMO and one had an open chest.

Fifty-four of the 100 patients met criteria for the early rehabilitation group, whereas 46 did not have PT consultation within the first 3 days of PICU admission (delayed rehabilitation). The median PICU LOS was 6 days (IQR: 4–11) in the early rehabilitation group and 4 days (IQR: 3–5) in the delayed rehabilitation group ($P < .001$).

Univariate analyses revealed that higher PRISM score ($P < .001$), baseline motor impairment ($P < .01$), baseline intellectual disability ($P = .04$), mechanical ventilation ($P = .1$), and number of continuously used devices ($P = .01$) were associated with early rehabilitation, whereas admission 1 or 2 days before the weekend ($P = .07$) was associated with delayed rehabilitation. These 6 factors were identified as variables for inclusion in the multivariable analysis (Table 2). Other respiratory support (noninvasive positive pressure ventilation, HHFNC oxygen therapy, and oxygen therapy) were not associated with early rehabilitation. Predictive factors for early rehabilitation in the logistic regression model were baseline motor impairment (adjusted odds ratio = 5.36, 95% CI: 1.3–22.0; $P = .02$) and higher PRISM score (adjusted odds ratio = 1.17, 95% CI: 1.02–1.34; $P = .02$; Table 3).

Discussion

Prior to the implementation of a unit-wide early mobilization program, we found that children with baseline motor impairment and higher PRISM scores were more likely to receive early rehabilitation, defined as rehabilitation team consultation within the first 72 hours of admission. These findings are reassuring in that the most critically ill children are more likely to have their rehabilitation needs addressed early, in contrast to our hypothesis that those patients would not have PT/OT involvement owing to a perception that they are

“too sick.” However, the findings from this study highlight a gap and significant opportunity to increase the awareness of rehabilitation needs for children who do not have baseline motor impairment or do not fit into the category of the most critically ill children. This study adds to our knowledge of PICU rehabilitation culture and factors that contribute to decisions to pursue early rehabilitation.

Patients with baseline motor impairment were 5 times more likely to have early rehabilitation by a PT in our study than those children with normal baseline function. This finding seems to be compatible with a general consensus that early mobilization by PTs is particularly advantageous for patients with baseline motor impairment. Most PICU staff members understand the importance of expert mobilization by a PT and appreciate the safety concerns of mobilization without PT involvement for children with physical impairments.^{12,25} Parents of children with baseline functional impairments may be more likely to advocate for physical and/or occupational therapy early because of their familiarity with the skillset of PTs and OTs and their experiences with therapy at home and in the hospital. Children admitted to the PICU with normal baseline function may not be perceived by PICU staff as high risk for long-term sequelae, suggesting knowledge gaps about the impact of bed rest for all patients. Therefore, PT/OT consultation may not be considered as a priority for these patients. However, recent data have shown that children with normal baseline motor function are at risk of long-term impairment and delays in recovery to baseline function. A 2015 pilot study by Choong et al¹⁹ found that less than 60% of children with normal baseline function had recovered to their baseline 6 months after critical illness.

Children with higher PRISM scores also were more likely to undergo early rehabilitation. As with baseline motor impairment, it is possible that PICU staff are more cognizant of the rehabilitation needs of the most severely ill patients and predict a longer LOS for these patients. In contrast, staff may expect a shorter LOS for less critically ill children and therefore consider PT/OT a lower priority. In a multicenter study, Choong et al²³ reported that factors associated with mobilization by a PT within 48 hours of PICU admission were older age, admission in winter, sedatives, and neuromuscular blockade. Although their study included pediatric cerebral performance category (PCPC) and PRISM 3 score as covariates, these were not associated with early rehabilitation.²³ This discrepancy may be attributable to the different measurements of those variables, as PCPC can be influenced by comorbidities other than motor impairment.

The PICU patients with no baseline motor impairment and low PRISM scores may benefit significantly from early rehabilitation with physical therapy, particularly if their ICU LOS is prolonged. Several studies that evaluated the implementation of a comprehensive early rehabilitation program for all ICU patients reported improved physical function, shortened LOS, and no increased cost.^{13–18,21} Thus, promoting early rehabilitation for all PICU patients (PT/OT consultation by PICU day 3) through implementing a unit-wide program with streamlined consultation criteria can be beneficial.²¹ Initiating early therapy consultation in the PICU even if the child is discharged by day 4 may facilitate continuity with rehabilitation on the floor setting and with discharge to home. However, the economic impact of early rehabilitation by PT/OTs needs to be examined through future studies to determine whether rehabilitation by PT/OTs is cost-effective when compared to mobilization

at the bedside by nurses and caregivers. It is possible that the children who are not receiving PT/OT services are having a significant proportion of their rehabilitation needs addressed by bedside nurses. A recent point prevalence study of adults with acute respiratory failure in the ICU found that 68% of mobility events were provided by nursing.²⁸

To our surprise, intervention-related variables such as mechanical ventilation and number of devices did not significantly influence early rehabilitation in our study. This result is consistent with our finding that higher PRISM scores were associated with early rehabilitation, as these patients are more likely to be mechanically ventilated and have more devices. Therefore, it is reassuring that device burden and mechanical ventilation do not affect staff perceptions about readiness for PT consultation.^{13,14,21} Other variables, including age, level of consciousness, sedative use, and neuromuscular blockade, were not statistically significant, although they have been considered to be possible risk factors for delayed rehabilitation.^{23,29}

Limitations

One major limitation to our study is that it is based on retrospective data; therefore, we cannot make determinations of causality. Identified factors need to be confirmed by future prospective and larger studies to determine whether these factors directly impact the timing of acute rehabilitation. Second, the primary outcome can be influenced by several unmeasured confounders, including an individual physician's practice and decision-making, personnel limitations, and institutional barriers. Finally, as a single-center QI study, generalizability to other PICUs may be limited owing to differences in hospital, PICU, and provider characteristics and practice.

Conclusion

Our study demonstrated that baseline motor impairment and higher PRISM scores were independently associated with the initiation of early rehabilitation, suggesting that at this center normal baseline motor function and lower acuity are risk factors for not involving PT in early rehabilitation. These findings highlight an overall PICU culture that must be optimized to enhance mobility for all critically ill patients. Implementation of a unit-wide early rehabilitation program with streamlined criteria for PT/OT consultation may be effective for reaching this goal.

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Table 1.Patient Characteristics.^a

Characteristic	Study Population (n = 100)
Age, months (IQR)	76.5 (27.5–160)
Body weight, kg (IQR)	19.3 (12.1–38.7)
Female sex	33
Admission category	
Medical	54
Surgical	46 (13 cardiac)
PRISM score (IQR)	5 (0–9)
Motor impairment	28
Intellectual disability	32
Neuromuscular disease	4
Cardiac disease	18
Weekend ^b	28

Abbreviations: IQR, interquartile range; PRISM, pediatric risk of mortality.

^aValues are provided as numbers for categorical variables and median (IQR) for continuous variables.

^bAdmission on Thursday or Friday.

Table 2.Univariate Analysis.^a

Characteristic	Early Rehabilitation (n = 54)	Delayed Rehabilitation (n = 46)	P Value
Age, months (SD)	99.1 (9.4)	85.7 (9.8)	.33
Female sex (%)	19 (35%)	14 (30%)	.62
Surgical admission (%)	27 (50%)	19 (41%)	.49
PRISM score (%)	6.44 (4.38)	3.46 (3.91)	<.001
Motor impairment (%)	22 (41%)	6 (13%)	<.01
Intellectual disability (%)	22 (41%)	10 (22%)	.04
Neuromuscular disease (%)	1 (2%)	3 (7%)	.24
Cardiac disease (%)	12 (22%)	6 (13%)	.23
Highest level of respiratory support			
Mechanical ventilation ^b (%)	20 (37%)	10 (22%)	.10
NIPPV (%)	6 (20%)	4 (11%)	.69
HHFNC (%)	7 (13%)	3 (6%)	.29
Face mask/nasal cannula (%)	12 (22%)	9 (20%)	.75
Number of devices (SD) ^c	5.26 (3.6)	3.65 (2.5)	.01
ECMO (%)	0	1 (2%)	.35
Open chest (%)	0	1 (2%)	.28
Deteriorated LOC (%)	29 (54%)	21.5 (47%)	.48
MDZ, mg/kg/d (SD)	0.077 (0.366)	0.027 (0.187)	.41
Morphine, mg/kg/d (SD)	1.10 (1.89)	0.97 (1.95)	.74
Pain scale ^d (SD)	2.81 (4.41)	2.56 (3.55)	.76
NMB (%)	2 (2%)	0	.19
Weekend ^e (%)	11 (20%)	17 (37%)	.07

Abbreviations: ECMO, extracorporeal membrane oxygenation; HHFNC, heated high-flow nasal cannula; LOC, level of consciousness; MDZ, midazolam; NIPPV, Noninvasive positive pressure ventilation; NMB, neuromuscular block-ade; PRISM, pediatric risk of mortality; SD, standard deviation.

^aValues are provided as number (percentage) for categorical variables and mean (SD) for continuous variables.

^bMechanical ventilation via an endotracheal tube or tracheostomy.

^cThe number of continuously used devices (arterial line, central venous line, peripheral venous line, Foley catheter, drains, intracranial pressure monitor).

^dPain was assessed on a scale of 0 to 10.

^eAdmission on Thursday or Friday.

Table 3.

Multivariable Analysis.

Characteristic	Odds Ratio (95% CI)	P Value
Age	1.00 (1.00-1.01)	.09
Female sex	2.04 (0.73–5.69)	.17
PRISM	1.17 (1.02-1.34)	.02
Motor impairment	5.36 (1.3–22.0)	.02
Intellectual disability	0.87 (0.23–3.3)	.84
Mechanical ventilation	1.8 (0.59–5.7)	.29
Number of devices	1.16 (0.96-1.4)	.12
Weekend ^a	0.41 (0.14–1.2)	.10

Abbreviations: CI, confidence interval; PRISM, pediatric risk of mortality.

^a Admission on Thursday or Friday.