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PICU Up!: Impact of a Quality Improvement Intervention to Promote Early Mobilization in Critically Ill Children

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Abstract

Objective—To determine the safety and feasibility of an early mobilization program in a pediatric intensive care unit (PICU).

Design—Observational, pre-post design.

Setting—PICU in a tertiary academic hospital in the United States.

Patients—Critically ill pediatric patients admitted to the PICU.

Intervention—This quality improvement project involved a usual-care baseline phase, followed by a quality improvement phase that implemented a multicomponent, interdisciplinary, and tiered activity plan to promote early mobilization of critically ill children.

Measurements and Main Results—Data was collected and analyzed from July to August 2014 (pre-implementation phase) and July to August 2015 (post-implementation). The study sample included 200 children aged 1 day through 17 years who were admitted to the PICU and had a length of stay of at least 3 days. PICU Up! implementation led to an increase in occupational therapy consultations (44% vs 59%; $p=0.034$) and physical therapy consultations (54% vs. 66%;

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$p=0.08$) by PICU day 3. The median number of mobilizations per patient by PICU Day 3 increased from 3 to 6 ($p<0.001$). More children engaged in mobilization activities after the PICU Up! intervention by PICU day 3, including active bed positioning ($p<0.001$) and ambulation ($p=0.04$). No adverse events occurred as a result of early mobilization activities. The most commonly reported barriers to early mobilization after PICU Up! implementation was availability of appropriate equipment. The program was positively received by PICU staff.

Conclusions—Implementation of a structured and stratified early mobilization program in the PICU was feasible and resulted in no adverse events. PICU Up! increased physical therapy and occupational therapy involvement in the children's care and increased early mobilization activities, including ambulation. A bundled intervention to create a healing environment in the PICU with structured activity may have benefits for short- and long-term outcomes of critically ill children.

Keywords

early mobilization; children; critical illness; acute rehabilitation; delirium; sleep; intensive care units

INTRODUCTION

The central focus of care in the pediatric intensive care unit (PICU) is on resuscitation, stabilization, management of critical disease processes, and reversal of organ failure. As a result, children are often sedated, restrained, and confined to bed for prolonged periods due to perceived benefits of safety, comfort, and hemodynamic stability (1). A culture of immobility may have several short- and long-term implications for critically ill children and their families (2-4), negatively affecting circadian rhythms and potentially increasing the risk of delirium (5-10). Ineffective positioning and limited mobility contribute to a high incidence of pressure ulcers in both infants and children (11-13). Moreover, children who survive their illness can experience residual perceptual-motor, psychiatric, and behavior problems as sequelae of critical illness (8).

Data from adult ICUs demonstrate that structured and interdisciplinary approaches to early mobilization are associated with reduced intensive care and hospital LOS, improved muscle strength and self-perception of functional status, and decreased sedation, delirium, and length of mechanical ventilation (14-17). Although pediatric literature regarding early mobilization practices is just emerging, available data indicate that early mobilization activities for the critically ill child are likely safe and feasible and may have short and long-term benefits (18-21).

The overall objective of this quality improvement (QI) project was to evaluate a structured and interdisciplinary early rehabilitation and progressive mobility protocol, "PICU Up!," for all critically ill children in a large, academic, tertiary-care PICU. Previously, the referral of children for therapy and mobilization was at the discretion of the medical providers without standardization or guidelines. The goals of PICU Up! were to provide a standardized, evidence-based, interdisciplinary mechanism to increase each child's activity level safely while simultaneously initiating and promoting a culture of mobility.

MATERIALS AND METHODS

Overview of Project Setting, Design and Patients

The PICU Up! Initiative was developed using an established and structured QI framework (described below in “Quality Improvement Process”) and evaluated using a pre-post design (22). The setting was the Johns Hopkins PICU, a 40-bed academic, tertiary care, combined medical-surgical unit with single-patient rooms that provides care for children from ages 1 day to 21 years. Registered nurse-to-patient ratios are 1:1 or 1:2 depending on patient acuity. Pediatric occupational therapist (OT), physical therapist (PT), and speech/language pathologist consultations and treatments are available when ordered by a medical provider. The PT and OT staff who care for children in the PICU also staff other units in the hospital. PICU Up! was implemented without any additional personnel or equipment resources.

A non-probability, convenience sampling strategy was used for program evaluation. Inclusion criteria were children aged 1 day to 17 years who required PICU admission for 3 or more days. Exclusion criteria included ECMO, open chest or abdomen, unstable fractures, or medical orders specifying alternate activities. Charts of the first consecutive 100 children who met inclusion criteria were reviewed retrospectively both before (July-August 2014) and after (July-August 2015) implementation of the mobility protocol. PICU Up! was implemented in March-May 2015. This QI project was comprehensively reviewed and acknowledged by the Johns Hopkins Institutional Review Board (IRB) as “quality improvement”, and did not require IRB approval.

Quality Improvement Process

The structured QI model used for the PICU Up! initiative aimed to create a change in practice through the “4 Es” approach: engage, educate, execute and evaluate (22). To achieve this, a collaborative interdisciplinary QI team, the PICU Up! Working Group, was created. Participation in the PICU Up! Working Group was open to all interested PICU staff. Active participants included at least one champion from each of the following groups: physicians, nurse practitioners, nursing, OT, PT, child life specialists, speech language pathology, respiratory therapy, and rehabilitation medicine. This core group of individuals met together on a weekly basis over 18 months to plan (engage and educate) the QI project prior to its execution and evaluation.

First, champions from the interdisciplinary team conducted focus groups with all stakeholders from their respective disciplines to present the problem and identify PICU-based facilitators and barriers to early mobilization. Second, the group worked together to develop guidelines for mobilization in the PICU based on the feedback provided from the focus groups and prior literature regarding early mobilization (14,22). Third, educational resources were developed for all PICU staff (“Staff Educational Resources,” below). Finally, the interdisciplinary team determined valid and feasible outcome measures based on previously published adult early mobilization QI studies to evaluate performance.

The PICU Up! Program

Components of PICU Up! included a tiered activity plan based on clinical parameters and exclusion criteria (Table 1). A foundation of PICU Up! was implementation of sleep hygiene promotion and routine delirium screening for all children. Each activity level was connected with a set of interventions, written to promote individualization based on the child's unique needs. Also included were criteria for pausing activity and reassessing the child before continuing the activity (Table 2).

It was determined that each child's activity level would be discussed and established during morning rounds, with the bedside nurse reporting the PICU Up! level (1, 2 or 3) based on the established criteria (Table 1). The interdisciplinary team caring for the patient considered the activity level and activity goal for the day during rounds. The bedside nurse recorded this information in the electronic record daily goals note, which was accessible to all providers, and assessed the appropriateness of the activity level throughout the day. Activities could be implemented by nursing and/or therapists based on their specific skills and the child's needs. The PICU Up! levels were intended to provide guidelines for appropriate activities, with the option to perform more advanced activities (i.e. ambulation of an intubated patient) with interdisciplinary team discussion individualized to the child.

Staff Educational Resources

Educational resources were presented in meetings, presentations and online communications to ensure involvement of all PICU stakeholders. A formal written procedure was available to staff via the Johns Hopkins online policies portal. Formal educational materials included a required 10-minute online learning module about early rehabilitation in critically ill patients, including a brief overview of relevant adult and pediatric literature. The module then transitioned into interactive case-based scenarios to illustrate application of the PICU Up! criteria (See Figures, Supplemental Digital Content 1-4), which demonstrate components of the online module). Because we identified a simultaneous need for pediatric delirium education among the staff (23), a parallel educational module for pediatric delirium utilizing the same interactive cases was developed. A pocket card that summarized the levels and activities was distributed to all staff members.

PICU Outcome Measures

Early mobilization was defined by the team as any passive or active activity that occurred within the first 3 days of PICU admission and was intended to maintain or restore musculoskeletal strength and function. At our institution, both PT and OT must be formally consulted by physicians or nurse practitioners to work with patients. PTs facilitate ambulation and mobility, while splinting, range of motion, seating, and positioning are the purview of OTs, with PT collaboration as needed. The primary outcome measures were 1) the proportion of patients with OT and/or PT consultations by PICU Day 3 and 2) the number and types of mobilization activities performed by PICU Day 3. Activities were categorized as in-bed therapies or mobility therapies. In-bed therapies included passive range of motion, active range of motion, and active or passive bed positioning, and splinting. Mobility activities included sitting at edge of bed, sit to stand, transfer, ambulation, and play. Secondary outcome measures were 1) the number of times and reasons that activities were

stopped, 2) barriers to activities, and 3) mobilization-related adverse events, including inadvertent extubation or line removal. Data for all outcome measures, including mobilization activities, adverse events and barriers were collected for each day of PICU admission in all patients. After implementation, a Likert-style four-question, voluntary and anonymous response questionnaire was sent to the entire PICU staff to collect general feedback about PICU Up! and ongoing barriers to mobilizing the critically ill child.

Statistical Analysis

Descriptive statistics were summarized as proportions for binary and categorical data. Continuous variables are presented as means $\pm$ SD or as medians with interquartile ranges, unless otherwise indicated. Unadjusted comparisons before and after implementation of PICU Up! were performed by using chi-square analysis, Fisher exact test, or the Wilcoxon rank-sum test, as appropriate. A 2-sided *P* value less than 0.05 was used to determine statistical significance. All data were analyzed with the statistical software package STATA version 12.0 (StataCorp LP, College Station, TX).

RESULTS

Patient Characteristics

Data was collected from 100 children who met inclusion criteria in the pre-implementation group (675 PICU days) and 100 children in the post-implementation group (737 PICU days). Characteristics of the pre- and post-implementation groups are summarized in Table 3. The groups were similar with regard to age, weight, PICU admission diagnoses, and Pediatric Risk of Mortality (PRISM) scores. The PICU Up! level did not differ between pre- and post-implementation groups at PICU day 3 ($p=0.79$).

Occupational and Physical Therapy Consultations

OT consultations increased significantly from the pre- to post-implementation phase by PICU day 3 (44% vs 59%; $p=0.034$). The number of PT consultations by PICU day 3 increased but did not reach significance (54% vs. 66%; $p=0.08$).

Activities

The total number of PICU mobilization activities in the first 3 days of admission were 465 pre-implementation and 769 post-implementation, respectively. As shown in Table 4, by PICU Day 3 the median number of mobilization activities per patient before and after PICU Up! implementation doubled from 3 to 6 (IQR 2-5 and 3-7.5, respectively; $p<0.001$). The proportion of children receiving at least one in-bed activity increased significantly from 70% to 98% ($p<0.001$). Although there was no change in passive range of motion, passive bed positioning, splinting or active range of motion, there was a significant increase in the number of children receiving active bed positioning (26% vs. 57%; $p<0.001$).

More children engaged in at least one mobility activity by day 3 after PICU Up! implementation (63% to 76%; $p=0.05$). However, there was no increase in the proportion of children who participated in sitting on the edge of bed, sit to stand, transfer, or play. After PICU Up! implementation, 27% of all children had ambulated by day 3, increased from 15%

pre-implementation ($p=0.04$). Among children greater than or equal to 3 years of age, 20% (10/50) ambulated prior to PICU Up! implementation, while 39% (22/56) ambulated after implementation ($p=0.03$). None of the 39 orally intubated children ambulated prior to PICU Up!, while 4 of 40 (10%) orally intubated children ambulated after PICU Up! implementation (See Figure, Supplemental Digital Content 5, which demonstrates a team-based approach to ambulation of the mechanically ventilated child).

Barriers to Activities and Adverse Events

Barriers to activities before and after PICU Up! Implementation in the first 3 days of PICU admission are shown in Table 5. Pre-implementation, the most frequently reported barriers to early mobilization activities as documented by nursing and/or therapists included procedures ($n=19$), patient condition ($n=10$) and bedrest orders ($n=3$). Post-implementation, the most frequently reported barrier was lack of equipment, specifically age and size-appropriate seating devices and positioning materials ($n=22$), which was reported only twice pre-implementation. Procedures were less frequently reported as a barrier ($n=10$) after PICU Up! implementation and patient condition continued to be reported with similar frequency ($n=11$).

No adverse events related to mobility, including unplanned extubations or line displacements, were reported in either phase of the program. In addition, there were no documented events of aborting mobilization activities once they had been initiated for hemodynamic, respiratory, pain, behavior, or pain criteria.

Feedback from PICU Staff

Ninety-five PICU staff responded to the post-implementation feedback questionnaire, and 58% of respondents were nurses. Most staff (95%) indicated that the PICU Up! levels were helpful in planning activities. Seventy-three percent reported that the pocket card was the most useful resource for daily use to increase knowledge regarding mobilization of the critically ill child, and 68% agreed that they had the support needed from team members to increase patient activity. Support from PTs and OTs was reported as a valuable personnel resource for mobilization. Barriers included not having adequate staff to mobilize the child while continuing to care for the other patients. Respondents also indicated that the medical team was not always sensitive to competing demands of the bedside caregivers when discussing mobilization.

DISCUSSION

Through a structured QI process, the PICU Up! Early Rehabilitation and Progressive Mobility Program established an interdisciplinary, multicomponent, and stratified intervention for critically ill children admitted to the PICU. Implementation of a bundled intervention to create a culture of mobility in the PICU was safe and feasible and facilitated the formal involvement of physical and occupational therapists in the care of critically ill children. Although PICU Up! led to increases in early mobilization activities of critically ill children, our QI initiative identified several areas for ongoing education and modification.

A structured and stratified approach to adult ICU rehabilitation has been shown to increase the success of mobility program implementation (14, 16, 24-28). In line with the adult literature, key factors that fostered a culture of mobility after PICU Up! implementation included 1) standardization of workflow, 2) facilitation of discussions regarding mobility goals during morning work rounds, and 3) identification of safe activities for each patient based on his/her acuity level and specific needs. Unlike the adult literature, data to support early rehabilitation in the PICU are limited to pilot studies, case series, and case reports (21). To our knowledge, this is the first report of a large-scale, multifaceted QI intervention aimed at promoting a culture of mobility in the PICU setting.

PICU Up! significantly increased the formal involvement of occupational and physical therapists in the care of critically ill children. These resources were determined to be the most valuable by all staff in creating a culture of PICU mobility. Like many adult and pediatric intensive care units nationally, our PICU does not have dedicated PT/OT staff (29), and because PTs and OTs care for children throughout the hospital, they must be formally consulted by physicians or nurse practitioners to work with PICU patients. Therefore, prior to implementation, we observed that PT/OT consultations were commonly delayed for the most critically ill children. This observation is consistent with a recent Canadian survey in which physiotherapists identified the need for a physician order as the major barrier to PICU rehabilitation (30). Before PICU Up! implementation, even when PT/OT consults were ordered early, nurses and/or physicians often would turn away therapy staff because they perceived that the patient's acuity was a contraindication to rehabilitation therapies. This was true particularly for intubated children. In addition to creating a framework for timely PT/OT consultation for all PICU patients, educating staff about the breadth of early mobilization activities and empowering PT/OT staff to advocate for therapy was crucial. Nurses also used PT/OT sessions to learn simple interventions from therapists that they could facilitate between sessions. Guidelines for stopping and reassessing children during therapy activities also enabled all staff involved to have a shared mental model.

The increase in OT consultations by PICU day 3 is consistent with prior pre-post implementation mobility studies investigating early activity in ICUs. Unlike programs demonstrating increased mobility activities as measured by billable PT units, we did not observe a significant increase in PT referrals by PICU day 3 (31). However, more children ambulated, suggesting that PICU Up! facilitated a transition to early ambulation through streamlined workflow and discussions.

Like other pediatric studies, our large-scale QI intervention did not result in any mobilization-related adverse events, such as inadvertent extubation (18-20). There were also no reports of a child needing to terminate activities early due to a decline in physiologic status or behavior. This finding is likely related to the fact that we designed the mobility levels based on the physiologic and developmental level of each child.

Barriers to implementation of early mobilization programs have been well-documented in the adult literature (17). For this QI study, additional resources were not allotted for personnel or equipment, and consistent with the adult ICU experience, PICU staff indicated through documentation and feedback that lack of appropriate equipment was a major

deterrent to mobilizing patients after PICU Up! implementation. Although the PICU Up! program provided a streamlined approach to early mobilization, specific activities could not be performed despite multidisciplinary team planning on morning rounds due to equipment barriers. Equipment challenges are further magnified in the pediatric population because of the heterogeneous nature of patients' heights and weights. Procedures were reported less frequently as a barrier after PICU Up!, suggesting that team coordination may improve the timing of early mobilization activities.

Finally, the exclusion criteria for PICU Up! were based on several factors. First, in order to ease the implementation phase, address safety concerns, and optimize acceptability of the program among staff, we chose to exclude ECMO patients in the initial PICU Up! rollout given the unique needs of this patient population. After the completion of this study, we have begun translating the PICU Up! principles to ECMO patients and are successfully increasing mobilization activities in this population. (See Figure, Supplemental Digital Content 6, which shows an adolescent on ECMO whose analgesia and sleep hygiene were optimized to enable wakefulness and communication during the day). The PICU Up! criteria will be modified after a pilot phase with ECMO-specific activity guidelines developed in conjunction with the ECMO team. Second, post-surgical patients with specific orders outlining mobilization restrictions were excluded from the initial implementation, although sleep hygiene and delirium screening were in place for all patients. The same applied for open chests and open abdomens. All in all, the vast majority of surgical patients were included in the PICU Up! program which was well-received by our surgeons.

This study had several important limitations. First, data collected from a convenience sample in a single academic pediatric hospital may limit the generalizability. Second, the retrospective nature of data collection is limited by the quality of documentation, specifically with regards to barriers. Third, only children who remained in the PICU for 3 or more days were included, limiting generalizability for short-stay patients. Fourth, we were unable to determine changes in delirium incidence given that delirium screening was not yet routine in the pre-implementation phase. Fifth, we did not measure the impact of PICU Up! implementation on resource utilization and workload, an important future direction for research given that most PICUs do not have dedicated PTs and OTs. Finally, data on sedative-analgesic dosing was not collected.

CONCLUSION

A multicomponent and interdisciplinary approach to early mobilization of children admitted to the PICU is feasible and resulted in no adverse events. PICU Up! increased the formal involvement of PTs and OTs and increased early mobilization activities including ambulation. Promoting and maintaining a culture of mobility in the PICU creates a strong foundation to investigate the effects of early mobilization on functional outcomes in critically ill children to potentially improve short and long-term outcomes while providing a healing PICU environment.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

PICU Up! Levels and Tiered Activity Plan.

Excluded from PICU UP! Levels and Activities	<ul style="list-style-type: none"> • ECMO • Open chest • Open abdomen • Unstable fracture • Medical orders specifying alternate activity 	
PICU UP! Level	Parameters for Inclusion	Activities
Level 1	<ul style="list-style-type: none"> • Intubated with FiO₂ >60% <u>or</u> • Intubated with PEEP > 8 <u>or</u> • Intubated difficult airway <u>or</u> • New tracheostomy <u>or</u> • Acute neurological event <u>or</u> • Sedated and SBS -3 to -2 <u>or</u> • Vasopressor – other than Milrinone 	<ul style="list-style-type: none"> • Lights on/shades up by 0900 • Bed/bath/weight by 2300 • Lights dimmed/out by 2300 – increase lighting as needed for cares/ interventions • TV limited to 30 minutes at a time and a goal of < 2 hours per day for children >2 years of age • HOB elevated 30° • Turn q2h during the day and q4h at night • Positioned in developmentally supportive position or as recommended by OT/PT • OT consult by PICU day 3 • PT consult as needed
Level 2	<ul style="list-style-type: none"> • Intubated or tracheostomy with FiO₂ 60% +/- PEEP 8 and SBS -1 to +3 <u>Or</u> • Non-invasive support with FiO₂ > 60% <u>or</u> • Dialysis/Renal Replacement Therapy <u>or</u> • Femoral access 	<ul style="list-style-type: none"> • Level 1 activities <u>plus</u> • Positive touch for infants/toddlers • Sitting up in bed TID • Team to consider OOB to chair +/- ambulation • OT/PT consult by PICU day 3 • Assess for difficulty with communication or phonation and consult SLP • Assess for swallowing readiness in high risk children and consult SLP • Assess need for daily schedule • psCAM-ICU or pCAM-ICU BID
Level 3	<ul style="list-style-type: none"> • Non-invasive pulmonary support with FiO₂ 60% <u>or</u> • Baseline pulmonary support <u>or</u> • EVD cleared by NUS and SBS-1 to +3 	<ul style="list-style-type: none"> • Level 1 and 2 <u>plus</u> • OOB to chair TID or sitting up in bed TID if appropriate chair is not available • Ambulate BID if trunk control present

PEEP: positive end-expiratory pressure; SBS: State Behavioral Scale; OOB: out of bed; SLP: speech language pathology; BID: twice a day; TID: three times a day; EVD: external ventricular drain; NUS: neurosurgery; pCAM-ICU: Pediatric Confusion Assessment Method-ICU; psCAM-ICU: Preschool Confusion Assessment Method-ICU

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Table 2

Criteria to “Rest and Reassess” from PICU Up! pocket card distributed to all staff. Vital sign changes based on baseline value prior to activity initiation.

•	Change in HR 20%
•	Change in BP 20%
•	Change in RR 20%
•	Decrease SaO2 15%
•	Increase FiO2 20%
•	Increase ETCO2 20%
•	Ventilator asynchrony
•	CPAP/BiPAP asynchrony
•	Respiratory distress
•	New arrhythmia
•	Hemodynamic concerns
•	Change in mental status
•	Concern for airway device, vascular access or EVD integrity
•	Behavior interfering with safe activity

HR: heart rate; BP: blood pressure; RR: respiratory rate; SaO2: oxygen saturation; ETCO2: end-tidal carbon dioxide

Table 3

Patient Characteristics

Characteristic	Pre-implementation (N=100)	Post-implementation (N=100)	P Value ^a
Age in years, mean (SD)	7.7 (5.6)	7.7 (5.4)	0.99
Weight in kg, mean (SD)	26.8 (19)	27.3 (22)	0.86
Gender			0.02 *
Male, n	67	51	
Female, n	33	49	
Admission categories			0.26
Medical, n	58	50	
Surgical, n	42	50	
Intubated on admission	39	46	0.32
Pre-existing conditions			
Motor impairment, n	29	26	0.63
Intellectual disability, n	32	27	0.44
PRISM score, mean (SD)	4.9 (4.4)	5.4 (4.5)	0.36
PICU LOS, mean (SD)	6.8 (5.4)	7.6 (6.9)	0.34
PICU Up! level – day 3			0.79
1, n	7	11	
2, n	18	17	
3, n	64	60	
Excluded, n	11	12	

LOS = length of stay; PRISM=Pediatric Risk of Mortality; PICU = pediatric intensive care unit.

^aDescriptive, t-test, and Chi-squared tests used for analysis.

* Statistically significant.

Table 4

Early Mobilization Activities: First 3 Days of PICU Admission

Activity n = number of children participating in that activity	Pre-implementation N = 100	Post-implementation N = 100	P Value ^a
In-bed activities (n)			
Passive range of motion	13	17	0.43
Passive bed positioning	41	47	0.39
Splinting	3	9	0.08
Active range of motion	2 (2)	2 (1)	0.99
Active bed positioning	26	57	<0.001 *
At least one bed activity	70	98	<0.001 *
Mobility activities (n)			
Sit edge of bed	6	11	0.20
Sit to stand	24	30	0.34
Transfer	48	46	0.77
Ambulate	15	27	0.04 *
Play	6	3	0.78
Other	5	3	0.31
At least one mobility activity	63	76	0.05 *

^aDescriptive, Fisher's Exact and Chi-squared tests used for analysis, as appropriate.

* Statistically significant.

Table 5

Barriers to Activities: First 3 Days of PICU Admission

n = number of times barrier reported	Pre-implementation	Post-implementation	<i>P</i> Value ^a
Barrier			<0.001
Child refused	0	3	
Parent refused	1	3	
Test/Study/Procedure/Surgery	19	10	
Patient Condition	10	11	
Equipment Availability	2	22	
Bedrest order	3	0	

^aFisher's Exact used for analysis.