Acute Rehabilitation Practices in Critically Ill Children: A Multicenter Study*

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***See also p. 571.**

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This study was performed at McMaster Children's Hospital, CHU Ste-Justine, Children's Hospital of Eastern Ontario, The Hospital for Sick Children, Toronto, Children's Hospital at London Health Sciences, and Stollery Children's Hospital.

Dr. Choong, Dr. Fraser, Dr. Hutchison, Dr. Joffe, Dr. Jouvet, Dr. Menon, Dr. Pullenayegum, and Ms. Ward were responsible for the study conception and design and interpretation of the data. Dr. Choong, Dr. Foster, and Dr. Pullenayegum were responsible for coordinating the data collection and statistical analyses. Dr. Choong drafted the manuscript and every author contributed to revisions and approved the final version. The members of the Canadian Critical Care Trials group are responsible for mentoring this study through their provision of advice on the study methodology and conduct, grant submission and review of the final manuscript.

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Objective: To evaluate acute rehabilitation practices in pediatric critical care units across Canada.

Design: Retrospective cohort study.

Setting: Six Canadian, tertiary care pediatric critical care units.

Patients/Subjects: Six hundred children aged under 17 years admitted to pediatric critical care unit during a winter and summer month of 2011 with a greater than 24-hour length of stay.

Interventions: None.

Measurements and Main Results: The primary outcome of interest was the nature and timing of pediatric critical care unit rehabilitation practices.Rehabilitation was classified according to mobility and nonmobility interventions. Predictors of mobilization and the time to mobilization were evaluated through regression and time-dependent survival analyses, respectively. The most common form of rehabilitation provided in pediatric critical care unit was physical therapy (45.5% patients) followed by occupational therapy (4.5%) and speech and language therapy (1.5%). Interventions were primarily nonmobility in nature (69.7% of sessions), most frequently in the form of chest physiotherapy (42.7% of sessions). The median time to mobilization was 2 days (interquartile range, 1–6) as compared with 1 day for nonmobility interventions (interquartile range, 1–3). Only 57 patients (9.5%) received early mobilization. Regression analyses revealed that increasing age, admission during winter, neuromuscular blockade, and sedative

infusions were associated with an increased likelihood of receiving mobility therapy. Increasing age was a predictor of early mobilization, while neuromuscular blockade was associated with delayed mobilization. No significant differences in adverse events were found between nonmobility and mobility interventions.

Conclusions: Only half of the children receive rehabilitation while in the pediatric critical care unit, and when it occurs, therapy is primarily focused on respiratory function. Mobilization appears to be reserved for at-risk children who were muscle relaxed and sedated; however, its implementation in these patients is delayed. Future pediatric-specific research is essential to identify patients at risk and to understand treatment priorities and rehabilitation strategies to improve functional recovery in critically ill children. (*Pediatr Crit Care Med* 2014; 15:e270–e279)

Key Words: acute rehabilitation; mobilization; pediatric critical care; physical therapy

Critically ill patients are often confined to bed rest for prolonged periods of time as they are perceived to be "too sick" to be mobilized (1). However, multiple adverse physical, neuromuscular, metabolic, and cognitive sequelae of immobility during critical illness are increasingly recognized (2). Survivors of critical illness are at risk of prolonged weakness, functional disability, and delayed recovery, resulting in suboptimal quality-of-life and high healthcare utilization costs (3–5). Emerging literature suggests that ICU-based early mobilization is feasible, safe, improves patient outcomes, and is cost-effective in adults (6–8). In contrast, pediatric-specific data are lacking. Prior to embarking on trials of early mobilization in children, evidence on whether children are at risk of similar morbidities as adults and an understanding of rehabilitation practices within pediatric critical care units (PCCUs) are essential. Rehabilitation methods and necessary resources to enhance recovery in critically ill children are currently poorly understood (9). There are numerous perceived barriers and diverse opinions regarding the appropriateness of rehabilitation in the PCCU setting (10). The primary objectives of this multicenter observational study were to evaluate acute rehabilitation practices in tertiary care PCCUs across Canada, the frequency of early mobilization, and barriers to mobilization in this population.

METHODS

This retrospective cohort study was conducted in six regional referral PCCUs in academic centers across Canada, following institutional research ethics board approval at each site. Patients aged 0–17 years admitted to the PCCU during winter (February) and summer (August) of 2011 with a greater than 24-hour length of stay were included. Direct patient transfers to PCCU from a neonatal ICU were excluded.

Outcome Measures

The primary outcome of interest was the nature of rehabilitation practices conducted in PCCU as described by their type, timing, and frequency. We defined "rehabilitation" as treatment or treatments designed to facilitate the process of recovery from injury, illness, or disease (11) and therefore included physical therapy (PT), occupational therapy (OT), and speech and language pathology. Rehabilitation could be provided by the following: physiotherapists, rehabilitation specialists (e.g., physiatrists and occupational therapists), nurses, respiratory therapist, or family caregivers. In order to capture all interventions considered as forms of rehabilitation reflective of current PCCU practice, we included nonmobility interventions such as cardiorespiratory PT (9, 12). For the purposes of identifying patients who were mobilized, interventions were classified into "nonmobility" and "mobility" types of therapies (**Appendix 1**, Supplemental Digital Content 1, http://links.lww.com/PCC/A104). Nonmobility interventions consisted of techniques to enhance cardiorespiratory function (chest PT), passive repositioning or stretching, whereas mobility therapy included activities focused on enhancing physical function and muscle strength (i.e., strengthening exercises, bed mobility, transfers, pregait activities, and ambulation). Based on current literature (8), we defined early mobilization as any mobility therapy performed within 48 hours of PCCU admission. Secondary outcomes included barriers to mobilization, clinical outcomes in patients who received mobility interventions compared with those who received only nonmobility or no rehabilitation, reported adverse events related to rehabilitation, and documented morbidities attributable to immobility (**Appendix 2**, Supplemental Digital Content 1, http://links.lww.com/PCC/A104). Standardized, pretested case report forms were developed with multidisciplinary input from co-investigators, research coordinators, pediatric physiotherapists, nurses, and respiratory therapists. Data were abstracted from patient medical records by trained research coordinators, and case report forms were transmitted from each site to the Biostatistics Unit in Hamilton via Teleform. Severity of illness was measured using validated scoring tools (the Pediatric Risk of Mortality [13] and Pediatric Logistic Organ Dysfunction (PELOD) scores [14]).The Pediatric Cerebral Performance Category (PCPC) and the Pediatric Overall Performance Category (POPC) scores were used to quantify cognitive and functional ability of each patient at baseline and on PCCU discharge (15).

Statistical Analysis

The study was powered to evaluate the probability of early mobilization. We approximated this rate at 20% based on previously reported frequencies in critically ill adults (1) and anecdotal evidence among participating PCCUs. We estimated that a sample size of 600 would enable us to present the probability of early mobilization with a 95% CI of ± 3.2% and allow us to evaluate up to 12 variables in a multiple logistic regression when exploring barriers to mobilization. Univariate comparisons for categorical data were computed using the chi-square or Fisher exact test if the expected values in any single cell were less than 5. Continuous data were compared using *t* test or nonparametric Wilcoxon rank test if data were skewed. Frequencies and types of rehabilitation interventions were quantified

descriptively using mean and SDs (16) or median and interquartile range (IQR) as appropriate. To explore predictors of mobilization, we regressed the presence of mobility therapy onto hypothesized barriers (vasoactive infusion use, mechanical ventilation, and invasive catheters) and confounding variables (markers of severity of illness) using a generalized estimating equation (GEE) with a logistic link and an exchangeable correlation structure to account for within-center clustering (17). Differences between centers were explored through logistic regression, with mobility therapy as the outcome and center as a fixed factor, adjusting for important confounding variables. Analysis was univariate in the first instance. In building a multivariable model, care was needed to avoid multicollinearity, as several of the predictors were highly correlated. For highly correlated variables, only one was selected as there was room for only one from each pair in the model. Otherwise, all variables were entered into the multivariable model regardless of their statistical significance on univariate analysis. To explore time-varying predictors of mobilization, we used a recurrent event analysis, implemented through a Cox proportional hazards model. Results were reported as odds ratios for binary outcomes and hazard ratios (HRs) for recurrent event analyses, with their respective 95% CI and associated *p* values. The criterion for statistical significance was set at $\alpha = 0.05$. All statistical analyses were completed using SAS (version 9.2; SAS, Cary, NC).

RESULTS

Data were abstracted and analyzed between March 2012 and April 2013. A total of 912 patients were admitted to the six participating PCCUs during the 2-month study period, 600 of whom fulfilled eligibility criteria and were included in the analyses (**Fig. 1**). The baseline demographics of these patients are presented in **Table 1**. There were 336 male patients (56%) and the mean age was 4.9 (SD, 5.7). The majority of patients (64.2%) were admitted with medical diagnoses, whereas 31% and 4.8% of patients were admitted following surgery and trauma, respectively. Fifty-six percent of patients had a preexisting or underlying chronic condition. Forty-three percent and 29.3% of patients had abnormal baseline functional and cognitive status, respectively, as indicated by their POPC and PCPC scores.

Rehabilitation Practice Patterns

Consultation for some form of rehabilitation was requested in 222 of 600 patients (37%). The majority of these consults were for PT (29%). The median time from PCCU admission to a written PT consult request was 1 day (IQR, 0–3), 2 days (IQR, 0–6) for OT, and 6 days (IQR, 1–15) for speech and language consults. The most frequent therapy requested by medical doctors was chest PT (50.5%), whereas in 27%, the type of rehabilitation requested was not specified (**Table 2**).

The commonest form of rehabilitation occurring within the PCCU was PT (45.5% patients) followed by OT (4.5%) and speech and language therapy (1.5%). Sixty-six (11%) and 77 (12.8%) received PT and OT, respectively, only after discharge

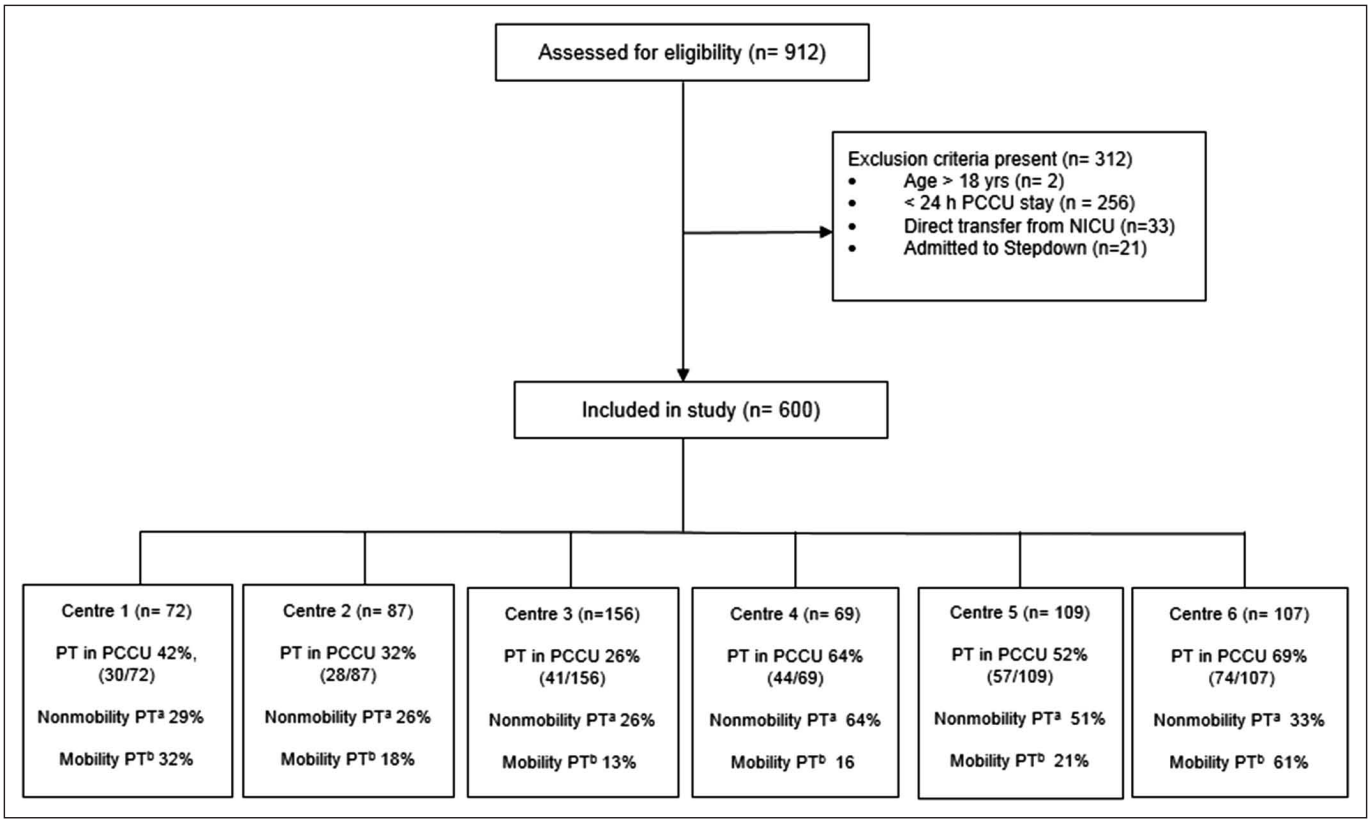

Figure 1. Participant flowchart and frequency of physical therapy at each participating critical care unit. PCCU = pediatric critical care unit, NICU = neonatal ICU, PT = physical therapy. [a]Patients who received any nonmobility PT; [b]Patients who received any mobility PT during their PCCU stay.

TABLE 1. Baseline Demographic Data of Patients

Variable	No. of Patients ($n = 600$)
Age (yr), mean (SD)	4.9 (5.7)
Males, *n* (%)	336 (56)
Admission period, *n* (%)	
Winter	384 (64)
Summer	216 (36)
Primary reason for admission, *n* (%)	
Medical[a]	385 (64.2)
Respiratory failure	160 (26.7)
Sepsis	57 (9.5)
Cardiovascular/shock	57 (9.5)
Neurologic	66 (11)
Metabolic	14 (2.3)
Poisoning/overdose	7 (1.2)
Hematologic	7 (1.2)
Gastrointestinal	6 (1.0)
Hemorrhage/coagulopathy	4 (0.6)
Renal failure	4 (0.6)
Malignancy	3 (0.5)
Trauma	29 (4.8)
Surgical	186 (31)
Elective postprocedure	159 (26.5)
Emergency surgery	30 (5)
Preexisting comorbidity/chronic condition, *n* (%)	336 (56)
Severity of illness scores, mean (SD)	
Pediatric Risk of Mortality III score at admission ($n = 600$)	5.9 (6.0)
Patients who never received rehabilitation in PCCU ($n = 327$)	5.5 (5.6)
Patients who received rehabilitation while in PCCU ($n = 273$)	6.4 (6.4)
Pediatric Logistic Organ Dysfunction at admission	9.1 (9.2)
Patients who never received rehabilitation in PCCU ($n = 327$)	8.1 (9.0)
Patients who received rehabilitation while in PCCU ($n = 273$)	10.3 (9.4)
Baseline (premorbid) PCPC score, mean (SD)	1.49 (0.92)
Patients who never received rehabilitation in PCCU ($n = 322$)	1.38 (0.78)
Patients who received rehabilitation while in PCCU ($n = 266$)	1.63 (1.05)
Distribution of PCPC scores, *n* (%)	
Normal (score of 1)	430 (71.7)
Mild disability (score of 2)	67 (11.2)
Moderate disability (3)	50 (8.3)
Severe disability (4)	40 (6.7)
Coma or vegetative state (5)	1 (0.2)
Baseline (premorbid) POPC score, mean (SD)	1.68 (0.96)
Patients who never received rehabilitation in PCCU ($n = 322$)	1.52 (0.82)
Patients who received rehabilitation while in PCCU ($n = 267$)	1.86 (1.08)
Distribution of POPC scores, *n* (%)	
Good overall performance (1)	342 (57.0)
Mild overall disability (2)	151 (25.2)
Moderate disability (3)	42 (7.0)
Severe disability (4)	53 (8.8)
Coma or vegetative state (5)	1 (0.2)

PCCU = pediatric critical care unit, PCPC = Pediatric Cerebral Performance Category, POPC = Pediatric Overall Performance Category.

[a]Medical denotes primary organ system disorder or medical diagnosis.

Pediatric Risk of Mortality III score, assessment range 0–74, with higher scores indicating a greater risk of death (13). Pediatric Logistic Organ Dysfunction score, assessment range 0–71, with higher scores indicating more severe organ dysfunction (14). Range for POPC and PCPC scores are 1–7, from 1 = normal, increasing scores indicating increasing disability, 6 = brain death, or 7 = cardiorespiratory death (15). Baseline denotes their premorbid condition prior to PCCU admission.

from PCCU. Of the 600 patients, 115 (19.2%) received nonmobility therapy exclusively, 158 (26.3%) received some form of mobility therapy, and 103 (17.2%) received a combination of nonmobility and mobility interventions. Only 57 patients (9.5%) received early mobilization. Three hundred twenty-seven patients (54.5%) did not receive any PT during their PCCU stay. Of the 273 patients who received PT, 131 (48%) did so without a written physician order, 43 (16%) of whom were mobilized, and 47 (17%) received strictly nonmobility PT. The commonest type of PT applied was chest PT (42.7% of sessions), while 30% of PT sessions were focused on mobility (**Table 2**).

The mean proportion of days during their PCCU stay on which PT occurred was 0.29 (SD, 0.39). Hundred one patients

TABLE 2. Pediatric Critical Care Unit Rehabilitation Practice Patterns

Variable	No. (% of 600 Patients)
MD orders for rehabilitation consults (%)	
Physiotherapy consult	174 (29.0)
Occupational therapy consult	29 (4.8)
Speech and language consult	9 (1.5)
Other consults specifically related to rehabilitation (%)	
Physiatry/rehabilitation medicine	5 (0.8)
Brain injury team	3 (0.5)
Respiratory therapy	2 (0.3)
Type of rehabilitation requested by MD, *n* (% of all requests)[a]	
Not specified	54 (27.1)
Chest physiotherapy	101 (50.7)
Passive repositioning or stretching	6 (3.0)
Mobility therapy	35 (17.5)
Mobility device (walker)	1 (0.5)
Splints	2 (1.0)
Patients who received any physical therapy during pediatric critical care units stay, *n* (% of 600 patients)	273 (45.5)
Nonmobility interventions	218 (36.3)
Chest physiotherapy	163 (27.2)
Passive repositioning or stretching	115 (19.2)
Exclusive nonmobility interventions	115 (19.2)
Mobility interventions	158 (26.3)
Strengthening/range of motion exercises	57 (9.5)
Bed mobility	46 (7.7)
Transfers	111 (18.5)
Ambulation	16 (2.7)
Exclusive mobility interventions	55 (9.2)
Nonmobility and mobility therapy	103 (17.2)
Time to first rehabilitation median (interquartile range) (d)	
Time to first rehabilitation intervention	1 (1–3)
Time to first nonmobility intervention	1 (1–3)
Time to first mobility intervention	2 (1–6)
Early mobilization (≤ 48 hr), *n* (%)	57 (9.5)
Type of physical therapy applied, total number of rehabilitation sessions (%)[b]	2,667
Nonmobility therapy	1,858 (69.7)
Chest physiotherapy	1,138 (42.7)
Passive repositioning/stretching	722 (27.1)
Mobility therapy, *n* (%)	809 (30.3)
Strengthening exercises/active range of motion	166 (6.2)
Mobility device	5 (0.2)
Bed mobility	191 (7.2)
Transfers	393 (14.7)
Pregait	12 (0.5)
Ambulation	42 (1.5)
% of rehabilitation sessions delivered by	
Physiotherapist	46.3
Registered nurse	44.3
Respiratory therapist	9.3
Occupational therapist	2.2
Family member	8.8

MD = medical doctor.

[a]Patients may have had more than one type of rehabilitation intervention requested. See Appendix 1, Supplemental Digital Content 1, http://links.lww.com/PCC/A104, for full definition of all types of rehabilitation interventions included.

[b]Some sessions were delivered by more than one therapist.

(16.8%) received PT daily while in PCCU. The median (IQR) duration of PT of any form was 3 days (2–5 d); patients received nonmobility therapy for a median of 3 days (2–5 d) and mobility therapy for 2 days (1–3 d). The median (IQR) frequency of nonmobility and mobility sessions per day PT was applied as 1 (0.2–2) and 0.2 (0–1), respectively. Rehabilitation was most frequently provided by physiotherapists (46.3% of sessions), followed by nurses (44.3%) (**Table 2**). Two of the 6 sites had written guidelines for rehabilitation (centers 3 and 6). There was a statistically significant variation among study sites with respect to the frequency of any PT ($p < 0.0001$) and mobility therapy ($p < 0.0001$) (**Fig. 1**).

Predictors of Mobilization

Univariate logistic regression analysis revealed that older age, increasing organ dysfunction as measured by PELOD, mechanical ventilation, vasoactive infusions, neuromuscular blockade, sedative infusion use, and admission during winter were associated with an increased likelihood of mobility therapy (**Table 3**). Following multivariable GEE analysis, increasing age, admission during winter, neuromuscular blockade, and sedative infusions were independent predictors of mobility therapy. After accounting for these factors, the remaining variables identified on the univariate analysis were no longer significant. Multivariable survival analysis revealed that increasing age was predictive of earlier mobilization (HR, 1.08; 95% CI, 1.05–1.11), whereas neuromuscular blockade

TABLE 3. Predictors of Mobilization in Critically Ill Children

	Univariate Analysis		Multivariable Analysis[a]	
Variable	OR (95% CI)	*p*	OR (95% CI)	*p*
Age (yr)[b]	1.08 (1.03–1.12)	0.0003	1.10 (1.05–1.16)	0.0001
Admitted month (winter vs summer)	1.47 (1.03–2.10)	0.036	2.15 (1.52–3.05)	< 0.0001
Pediatric Risk of Mortality III score[c]	1.006 (0.99–1.02)	0.541	0.97 (0.93–1.01)	0.13
Pediatric Logistic Organ Dysfunction[c]	1.018 (1.007–1.03)	0.001	–	–
Pediatric Cerebral Performance Category[c]	0.89 (0.67–1.18)	0.420	–	–
Pediatric Overall Performance Category[c]	1.00 (0.85–1.17)	0.981	0.97 (0.78–1.20)	0.78
Mechanical ventilation	1.58 (1.08–2.31)	0.018	1.28 (0.88–1.85)	0.19
Vasoactive infusion	1.74 (1.05–2.89)	0.031	1.52 (0.82–2.81)	0.18
Invasive devices	1.87 (0.89–3.93)	0.096	1.30 (0.71–2.40)	0.39
Neuromuscular blockade	7.66 (4.01–14.62)	< 0.0001	4.54 (2.9–7.05)	< 0.0001
Sedative infusions	2.06 (1.36–3.11)	0.0006	1.58 (1.22–2.06)	< 0.0001
Systemic steroid use	1.60 (0.89–2.86)	0.116	1.61 (0.92–2.81)	0.09

OR = odds ratio.

[a]Multivariable generalized estimating equation analysis. Pediatric Risk of Mortality (PRISM) and Pediatric Logistic Organ Dysfunction (PELOD) contain many common items and were highly correlated. PRISM was therefore selected in order to also include mechanical ventilation in the model (if PELOD was included, mechanical ventilation would need to be excluded in the model). Similarly Pediatric Cerebral Performance Category (PCPC) and Pediatric Overall Performance Category (POPC) were also highly correlated (correlation 0.85); hence, POPC was selected for the multivariable model.

[b]Odds for increasing years of age.

[c]Odds for increasing baseline score.

PRISM III score, assessment range 0–74, with higher scores indicating a greater risk of death (13). PELOD score, assessment range 0–71, with higher scores indicating more severe organ dysfunction (14). Assessment range for POPC and PCPC scores are 1–7, where 1 = normal, increasing scores indicate increasing disability, 6 = brain death, or 7 = cardiorespiratory death (15).

TABLE 4. Predictors of Time to Mobilization in Critically Ill Children

	Univariate Analysis		Multivariable Analysis	
Variable	Hazard Ratio (95% CI)	*p*	Hazard Ratio (95% CI)	*p*
Age (yr)	1. 08 (1.05–1.11)	< 0.0001	1.08 (1.05–1.11)	< 0.0001
Admission month (winter vs summer)	1.37 (0.85–2.20)	0.200	–	–
Pediatric Risk of Mortality III	0.98 (0.94–1.02)	0.395	–	–
Pediatric Logistic Organ Dysfunction	1.00 (0.98–1.02)	0.832	–	–
Baseline Pediatric Overall Performance Category	0.85 (0.69–1.05)	0.134	–	–
Baseline Pediatric Cerebral Performance Category	0.89 (0.71–1.12)	0.320	–	–
Mechanical ventilation	0.454 (0.299–0.690)	0.0002	0.66 (0.39–1.12)	0.122
Vasoactive infusion	0.60 (0.38–0.95)	0.029	1.05 (0.67–1.63)	0.832
Sedative infusion	0.55 (0.38–0.79)	0.001	0.80 (0.49–1.30)	0.3688
Neuromuscular blockade	0.26 (0.15–0.45)	< 0.0001	0.39 (0.23–0.67)	0.0006

[a]Cox proportional hazards model. The recurrent event of interest was mobility therapy, which was initially regressed onto each predictor in turn in the univariate analyses. Predictors that were significant on univariate analysis were entered into a multivariable model. Mechanical ventilation, sedative infusion, vasoactive infusion, and neuromuscular blockade were treated as time-dependent covariates.

was associated with delays in mobilization (HR, 0.39; 95% CI, 0.23–0.67) (**Table 4**). Mechanical ventilation and sedative infusion use were not significantly associated with delays to mobility PT. The most frequently recorded reasons for not applying rehabilitation while in PCCU are outlined in **Table 5**.

Patient Outcomes

Patient outcomes and comparisons according to the type of rehabilitation received are shown in **Table 6**. The overall mortality rate was 4.7%. There was a significantly greater duration of vasoactive infusion use, length of PCCU stay, and PCCU delirium among patients who were mobilized compared with those who were not. There were a greater number of patients with decubitus ulcers among those who received mobility therapy compared with those who did not. There were no statistical differences in adverse events such as hemodynamic instability, respiratory decompensation, tube dislodgements, or patient intolerance during nonmobility compared with mobility therapy (**Supplemental Table 1**, Supplemental Digital Content 1, http://links.lww.com/PCC/A104).

TABLE 5. Documented Reasons for Deferring Rehabilitation

Reason	Never Received Rehabilitation in PCCU (*n* = 327 Patients)[a]	Received Rehabilitation in PCCU (*n* = 273 Patients)[a]
Not specified or recorded	236 (57.9)	242 (61.4)
Patient deemed too sick	16 (3.9)	21 (5.3)
Patient too well	7 (1.7)	22 (5.6)
Per MD orders	37 (9.1)	22 (5.6)
No MD order	97 (23.8)	74 (18.8)
Patient unavailable (e.g., on transport or procedure)	9 (2.2)	4 (1.0)
Patient/parent refusal	4 (0.9)	0 (0.0)
Staff availability	0 (0)	1 (0.2)
Presence of indwelling catheters	1 (0.2)	8 (1.9)
Equipment limitation	0 (0.0)	0 (0.0)

PCCU = pediatric critical care unit, MD = medical doctor.

[a]Results are presented as number (%) of total reasons provided. There were 407 and 394 reasons provided for the no rehabilitation and rehabilitation groups, respectively.

TABLE 6. Patient Outcomes, According to Rehabilitation Type Received While in Pediatric Critical Care Unit

Variable	All Patients (*n* = 600)	No Mobilization[a] (*n* = 442)	Mobility Therapy[a] (*n* = 158)	Test Statistic[b]; *p*
PCCU mortality, *n* (%)	28 (4.67)	24 (5.42)	4 (2.53)	2.04; 0.153
Duration of mechanical ventilation,[c] median (IQR) days	1 (1–3)	1 (1–2.25)	1.5 (1–5.75)	2,456; 0.163
Duration of vasoactive infusions,[d] median (IQR) days	2 (1–6)	2 (1–4)	4 (1–9)	23,418; 0.001
Length of stay in PCCU, median (IQR) days	3 (2–6)	3 (2–5)	5 (2–12)	47,055; < 0.001
Decubitus ulcers, *n* (%)	5 (0.83)	0 (0.0)	5 (3.16)	14.10; 0.001
PCCU-acquired weakness, *n* (%)	5 (0.83)	2 (0.45)	3 (1.98)	2.94; 0.117
Joint contractures, *n* (%)	2 (0.33)	0 (0.0)	2 (1.27)	5.61; 0.069
New onset deep venous thrombosis, *n* (%)	1 (0.17)	1 (0.23)	0 (0.0)	0.36; > 0.999
PCCU delirium	3 (0.5)	0 (0.0)	3 (1.98)	8.43; 0.018

PCCU = pediatric critical care unit, IQR = interquartile range.

[a]No mobilization refers to patients who either did not receive any rehabilitation or received nonmobility therapy only, during their PCCU stay. Mobility therapy refers to patients who received mobility rehabilitation interventions at any time during their PCCU stay.

[b]Chi-square test for categorical variables (Fisher exact test where appropriate); Mann-Whitney *U* test for continuous variables.

[c]Total number of patients who were mechanically ventilated, *n* = 421; mobility group, *n* = 122; nonmobility only group, *n* = 101; no rehabilitation group, *n* = 198.

[d]Total number of patients received vasoactive infusions, *n* = 213; mobility group, *n* = 72; nonmobility only group, *n* = 38; no rehabilitation group, *n* = 103.

DISCUSSION

Rehabilitation interventions in critically ill patients cover a wide range of techniques (12). Given the paucity of pediatric evidence, we conducted this study to understand current forms of rehabilitation applied in critically ill children, particularly with respect to the frequency and timing of mobility compared with other interventions, and potential barriers to mobilization. Our results revealed that approximately half the children with a greater than 24-hour PCCU stay received some form of rehabilitation during their critical illness, most commonly in the form of chest PT and nonmobility type therapies. Although chest PT is the most common intervention applied in this population (9, 18, 19), the evidence for its effectiveness is conflicting as it has not been demonstrated to facilitate weaning from mechanical ventilation, shorten ICU or hospital length of stay, or decrease mortality in adults or children (20). In contrast, exercise-based or mobility PT initiated as early as possible in critically ill adults has been shown to improve peripheral and respiratory muscle strength and physical function and increases ventilator-free days thereby reducing ICU and hospital length of stay, in comparison with nonmobility type interventions (8, 21). Early mobility is therefore increasingly recommended as a matter of priority in adult ICUs (21, 22). Mobilization did not appear to be a priority for critically ill children in this study, as only 9.5% were mobilized early. Although 26% of children were mobilized, mobility was most often delayed following nonmobility interventions.

The proportion of children who received mobility PT is comparable to adult data published prior to early mobilization recommendations, where a range of 6–34% of critically ill adults was routinely mobilized (23–25). Mobilization in this study was more likely to be implemented in older children, perhaps due to their cognitive and functional maturity to comply with these activities, and a perception of greater safety by therapists in mobilizing older children. We observed that increasing severity of illness scores, mechanical ventilation, and vasoactive and/or sedative infusion use were not significant barriers to mobilization. Indicators of severity of illness were in fact associated with an increased likelihood of mobilization. However, the time to mobilization particularly in the presence of neuromuscular blockade was more likely to be delayed. Children admitted during a winter month were more likely to receive mobility therapy. This may reflect the higher seasonal admission rate and acuity during the winter compared with summer months, as is typical in pediatrics (26). Sicker patients had longer PCCU stays, which may have increased their opportunity to receive mobility PT.

Therapy in this study of critically ill children was primarily focused on respiratory function and airway secretion clearance rather than optimizing muscle strength through mobilization. This observed practice pattern may be explained by the following: 1) the nature of the PCCU population—the majority of admissions were for respiratory failure and postoperative stabilization, rationalizing the emphasis on respiratory function; 2) recurrent aspiration syndromes are common in this population, resulting in a perceived need for frequent chest PT; 3) underlying cognitive and functional disability is common among critically ill children, presenting an actual or perceived barrier to applying mobility PT; 4) there is a paucity of prospective evidence quantifying the incidence of ICU-acquired weakness in children, a key predictor of delayed functional recovery in adults; and 5) there is a lack of efficacy data on early mobilization on PCCU and post-PCCU outcomes and how to operationalize such interventions safely in a broad range of critically ill children. Delays in mobilization may be explained by resource limitations. Only half of Canadian PCCUs have access to physiotherapists, and the majority of physiotherapists working in a PCCU are not dedicated to that ward (9, 10). This may explain why mobility PT, which may require more time and perhaps several individuals to execute in a single patient, was reserved for sicker patients perceived to be most in need of this therapy.

Although early rehabilitation is supported by the majority of Canadian PCCU clinicians, there are safety concerns and a lack of knowledge regarding the most appropriate strategies to implement in critically ill children (10). This was reflected by the infrequent physician orders for rehabilitation in this study and the lack of specified form of therapy requested when PT was ordered. Subsequently, almost half of children who received PT did so without a physician request. PT may have been independently deemed appropriate and applied in these patients by the physiotherapist, nurse, or respiratory therapist. Physicians are generally not the first healthcare providers to recognize a child's need for rehabilitation and admit to knowledge gaps in this area (10). In contrast, physiotherapists have the requisite expertise to evaluate patients at risk and in need of specific rehabilitation. However, the lack of PCCU practice guidelines makes it challenging to implement routine evaluations of rehabilitation priorities, to ensure that appropriate strategies are initiated in a safe and timely manner. Interestingly, the rate of PT was not significantly greater in two of the six centers that reported using guidelines. Without knowing the nature of these guidelines and how they are operationalized, we are unable to comment on the reason for this observation. The rate of OT and speech therapy was very low, perhaps reflective of the patient mix in this general critically ill pediatric cohort, clinician awareness of the need for these services, a prioritization of care within the PCCU, and the timing at which these forms of rehabilitation can be appropriately implemented. More patients received OT after PCCU discharge than during their PCCU stay. These findings are not inconsistent with previous reports, where only 19% of traumatic brain injury patients receive OT in hospital (27).

The mortality and morbidity rates were low in this study, consistent with previous reports (28, 29). Some of the morbidities attributable to prolonged immobility appeared to be more significant among patients who received mobilization therapy compared with those who did not. A limitation of this retrospective study is the inability to ascertain temporal relationship—the onset of decubitus ulcers and joint contractures may in fact have prompted mobility therapy. Early mobilization was infrequent; hence, we hypothesize that delays in mobilizing sicker patients did not allow for potential prevention of these

morbidities. Given the small numbers of affected patients, we interpret these results with caution and acknowledge the potential for reporting and ascertainment bias of clinical outcomes as a weakness of this study. We were also unable to assess functional recovery following PCCU discharge and its association with PCCU-based rehabilitation in this retrospective design. Strengths of this study are that it is the first to our knowledge to provide us with an understanding of rehabilitation practice patterns and related outcomes among Canadian PCCUs. We attempted to minimize bias through the use of standardized, pretested data collection forms, a procedure manual of definitions and formal training of data collectors. Our selection of six moderate- to large-sized mixed medical-surgical PCCUs allowed us to evaluate representative Canadian PCCUs and generalize some of our findings. We observed practice variations among these PCCUs, which we attribute to factors such as resource allocation, perceptions of rehabilitation, lack of institutional guidelines, and the presence of a champion (10). Although we were unable to assess resource utilization, indications for, or clinician's impressions influencing the observed practice patterns within this retrospective design, this study allowed us to complement stated practice (10), with an evaluation of actual practice to better understand acute rehabilitation practices among Canadian PCCUs. Perceived barriers to rehabilitation do not appear to be barriers to implementation but to timely initiation.

Approximately half of the children in this study had an abnormal baseline functional status, and half the rehabilitation sessions were delivered by nonphysiotherapists, including family members (8.8% of sessions). This speaks to the need to acknowledge the growing proportion of children with complex comorbid conditions populating our PCCUs and the increasing resources required to optimize their care (9, 29). As pediatric-specific evidence emerges, the participation of family caregivers in providing rehabilitation may facilitate its delivery, particularly in resource-limited settings. Although mobility PT appeared to be reserved for sicker patients, most of the time was spent applying chest PT. It remains to be seen whether early mobilization and/or chest PT techniques focused on lung recruitment and optimizing secretion clearance can impact on meaningful outcomes in critically ill children. The case mix and nature of the PCCU population, where respiratory infections are common and ICU-acquired weakness to our knowledge is not, do not allow us to extrapolate from adult data and warrant pediatric-specific evidence. This study describing practice patterns is an essential first step. Future prospective pediatric research should be directed toward evaluating the effects of specific PT strategies and elucidating mechanisms responsible for possible effectiveness. Although rehabilitation is an expected and integral part of PCCU care, there are currently no evidence-based guidelines for PT in critically ill children (30, 31).

CONCLUSIONS

Half of critically ill children admitted to Canadian PCCUs do not receive acute rehabilitation. When implemented, therapy is primarily focused on chest PT, which has not been shown to improve clinically important outcomes in critically ill children. Although mobilization appears to be reserved for the sickest children who were muscle relaxed, sedated, and therefore at highest risk of morbidity, its institution in these patients is delayed. As survival rates continue to improve and the prevalence of complex chronic conditions in the PCCU continues to grow, our focus should shift beyond survival, to the prevention and management of the complications of critical illness and critical care, and the optimization of recovery. Future pediatric-specific research is essential to understanding what rehabilitation interventions should be prioritized in a PCCU setting, how it can be safely instituted in a timely manner, and by whom. Such research will be the basis of much needed practice guidelines, enable risk stratification of children who may benefit from specific forms of rehabilitation, and support appropriate resource allocation and physiotherapist autonomy in keeping with their expertise.

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