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Clinical paper

A pragmatic checklist to identify pediatric ICU patients at risk for cardiac arrest or code bell activation ☆

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ABSTRACT

Background: In-hospital cardiac arrest is a rare event associated with significant morbidity and mortality. The ability to identify the ICU patients at risk for cardiac arrest could allow the clinical team to prepare staff and equipment in anticipation.

Methods: This pilot study was completed at a large tertiary care pediatric intensive care unit to determine the feasibility of a simple checklist of clinical variables to predict deterioration. The daily checklist assessed patient risk for critical deterioration defined as cardiac arrest or code bell activation within 24 h of the checklist screen. The Phase I checklist was developed by expert consensus and evaluated to determine standard diagnostic test performance. A modified Phase II checklist was developed to prospectively test the feasibility and bedside provider "number needed to train".

Results: For identifying patients requiring code bell activation, both checklists demonstrated a sensitivity of 100% with specificity of 76.0% during Phase I and 97.7% during Phase II. The positive likelihood ratio improved from 4.2 to 43.7. For identifying patients that had a cardiac arrest within 24 h, the Phase I and II checklists demonstrated a sensitivity of 100% with specificity again improving from 75.7% to 97.6%. There was an improved positive likelihood ratio from 4.1 in Phase I to 41.9 in Phase II, with improvement of "number needed to train" from 149 to 7.4 providers.

Conclusions: A novel high-risk clinical indicators checklist is feasible and provides timely and accurate identification of the ICU patients at risk for cardiac arrest or code bell activation.

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Introduction

More than 6000 children in the United States receive in-hospital cardiopulmonary resuscitation (CPR) each year. Most of these events occur in pediatric intensive care units (PICUs) [1,2] with more than 67% attain return of spontaneous circulation following CPR.[3] Among hospitals participating in the American Heart Association Get With The Guidelines-Resuscitation (GWTG-R)

program, survival to discharge rates have improved from 25% in 2000–2005 to 40% since 2006 with 70–90% having favorable neurologic outcomes.[1,4]

In-hospital cardiac arrest is frequently preceded by early warning signs of clinical deterioration that can be recognized and treated by trained in-hospital staff.[5] The implementation of early warning scores [6–13] and rapid response systems [14–16] suggest improved recognition and treatment of clinical deterioration in hospitalized patients on the general wards. However, there is little data on the ability to further identify the patients at greatest risk for cardiac arrest (CA) in a PICU. The improvement in recognition, situational awareness, and training amongst healthcare providers in the complex, high-stress setting of a PICU may have an important impact on patient outcomes.

In our previous studies, we demonstrated intense just-in-time training, CPR feedback, and after-event review (debriefing) can improve survival outcomes.[3,17–19] To improve effectiveness and

efficiency of just-in-time education and training, we need a tool to identify patients who are at risk for critical deterioration, defined as cardiac arrest (CA) or code bell activation (CBA). This study was focused on development and validation of a tool to identify PICU patients at risk for CA or CBA using a simple checklist.

In this report, we describe the derivation, initial validation, modification, and prospective validation of a simple, feasible CA or CBA event screening checklist designed to identify patients at risk for CA or CBA event in a 55-bed, tertiary care medical/surgical PICU. We hypothesized that a simple, focus-group, and expert consensus-derived CA and CBA event screening checklist would be highly predictive to detect PICU patients who would ultimately have a CA or CBA within 24 h, with a positive likelihood ratio of more than 10.

Methods

Design and setting

The study PICU is a tertiary care pediatric medical/surgical ICU with 55 beds and averages over 3500 admissions per year in each of the past 5 years. The cardiac surgical ICU and neonatal ICU were excluded. This was a pilot study with the primary objective of determining the feasibility of implementing a simple screening checklist to pre-identify those PICU patients at highest risk for a CA or CBA event within 24 h of screening. Our expert consensus decided *a priori* that the desired sensitivity should be greater than 98% with the specificity greater than 80% to achieve a clinically useful positive likelihood ratio of >10. A positive likelihood ratio of >10 is generally accepted as a large and conclusive increase in the likelihood of disease detection.[20,21] This study was conducted as ancillary to a larger trial to quantitatively characterize CPR quality in the PICU.[3] The study protocol was approved by the Institutional Review Board at The Children's Hospital of Philadelphia.

Phased checklist development

Our expert consensus group, comprised 10 experts in critical care, emergency medicine, and pediatric early warning scores research collaborated to propose easily identifiable and specific data elements to detect patients in the PICU at highest risk for a CA event within the following 24 h. In Phase I, a 10-point checklist (Table 1) was developed by consensus consisting of clinical indicators that were considered easy to assess from the patient's doorway, electronic medical record, and laboratory report screen, while incorporating bedside provider intuition. After an initial pilot testing for 15 consecutive weekdays, our team analyzed the results, reconvened with clinical experts, and modified the checklist to include more explicit criteria of 15 discrete elements (Table 2) modifying the criteria and operational definitions for respiratory support and adding additional simple metabolic parameters to the checklist. Operational definitions of criteria are explicitly listed in Appendix 1. In order to prospectively test the likelihood ratios, sensitivity, specificity, positive predictive value, and negative predictive value of this revised checklist, our research coordinators pre-rounded daily for less than 10 min/day with the clinicians and nurse managers, between the hours of 7 am and 8 am for 15 consecutive weekdays during Phase I and for 95 consecutive weekdays during Phase II.

Data collection and analysis

At the end of each screening period, we compared those patients identified as high-risk by daily checklist screening (meeting any one of the criteria) to those patients who required (1) CBA and/or (2) had a CA in the 24 h following a positive checklist screen.

Table 1

High risk clinical indicators checklist, version 1. This checklist was applied during Phase I to identify patients at risk for CA or CBA. Please see Appendix 1 for definitions of clinical parameters.

Phase 1: PICU high risk clinical indicators checklist (check all that apply)[a]	
Respiratory	☐ PEEP > 12 or PEEP > 10 and FiO$_2$ > 60%
	☐ Nitric oxide therapy >5 ppm
Circulatory	☐ ECMO
	☐ Recent cardiac arrest (<48 h)/ALTE with continued cardiovascular instability
	☐ Use of two vasoactive medications (dopamine >5 min) or single drug with dopamine >10, epinephrine/norepinephrine >0.25
	☐ High risk of arrhythmogenic arrest (ingestions/long QT)
Neurologic	☐ Traumatic brain injury elevated intracranial pressure sustained >20 with need for blood pressure augmentation to support cerebral perfusion pressure
Metabolic	☐ Ongoing treatment of life–threatening metabolic derangements (hyperammonemia, hyperkalemia, severe acidosis (pH < 7.25)
Other	☐ Life threatening procedure planned (high risk of known complications, difficult airway)
	☐ Provider intuition—reason:td:paraenter

[a] Any one or combination of risks may indicate that patient is at high risk for cardiac arrest. Other criteria may apply and confirmation should be made with patients' clinical management team.
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Standard diagnostic test evaluation was used to determine likelihood ratios, sensitivity, specificity, positive predictive value, and negative predictive value for each checklist version. In order to help define the usefulness and feasibility of this tool to be utilized prospectively for just-in-time education and training, we also defined a "number needed to train" (NNT). This number signifies the number of patients who would screen positive by the checklist and whose providers would need to receive "just-in-time" resuscitation education training, for every one patient who actually experienced a CA or CBA within 24 h of screening. For instance, a "number needed to train" of 5, would mean that for every 5 patients who screened positive by checklist criteria (and their bedside providers just-in-time trained), one patient would actually have a CA or CBA.

Table 2

High risk clinical indicators checklist, version 2. This checklist was applied during Phase II to identify patients at risk for CA or CBA. Please see Appendix 1 for definitions of clinical parameters.

Phase 2: High risk clinical indicators checklist (check all that apply)[a]	
Respiratory	☐ MAP >20
	☐ Nitric oxide therapy >5 ppm
Circulatory	☐ ECMO
	☐ Recent cardiac arrest (<24 h)
	☐ Use of 2 vasoactive medications (dopamine >5 min) or single drug with dopamine >10; epinephrine/norepinephrine >0.25
	☐ Recent life threatening event requiring code team activation (e.g., BPD spell, pulmonary hypertension, ALTE)
	☐ Stage I repair <24 h
Neurologic	☐ Traumatic brain injury elevated intracranial pressure sustained >20 with need for blood pressure augmentation to support cerebral perfusion pressure
Metabolic	☐ PICU initiated Renal Replacement Therapy
	☐☐ Potassium > 7.0
	☐ pH < 7.15
	☐ Lactate > 10
High Risk Procedure	☐ Intubation/extubation of known difficult airway
	☐ Intubation of known diagnosis of myocarditis
Other	☐ Provider Intuition (e.g., patient too unstable for daily care)

[a] Any one or combination of risks may indicate that patient is at high risk for cardiac arrest. Other criteria may apply and confirmation should be made with patients' clinical management team.
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