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Clinical paper

Pediatric extracorporeal cardiopulmonary resuscitation during nights and weekends☆

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ABSTRACT

Aim: Extracorporeal cardiopulmonary resuscitation (ECPR) is a lifesaving rescue therapy for patients with refractory cardiac arrest. Previous studies suggest that maintaining a 24/7 in-house surgical team may reduce ECPR initiation time and improve survival in adult patients. However, an association between cardiac arrest occurring during off-hours and ECPR outcome has not been established in children.
Methods: This is a single institution, retrospective review of all pediatric patients who received ECPR from December 2008 to August 2015.
Results: During the study period, ECPR was performed 54 times in 53 patients (20 weekday, 34 night/weekend). Interval from ECPR activation to initiation of extracorporeal life support was significantly longer during night/weekends (49 min night/weekend vs. 33 min weekday, $p < 0.001$) as was the interval from ECPR activation to incision for cannulation (26 min night/weekend vs. 14 min Weekday, $p < 0.001$). Rate of central nervous system (CNS) injury was higher in the night/weekend group (43% night/weekend vs. 15% weekday, $p = 0.04$), with associated 75% mortality prior to hospital discharge. Time of arrest did not impact survival to hospital discharge (44% night/weekend vs. 55% weekday, $p = 0.57$), one-year survival (33% night/weekend vs. 44% weekday, $p = 0.44$), or neurologic outcome (Pediatric Cerebral Performance Score at 1-year post-ECPR, 1.45 weekday vs. 1.50 night/weekend, $p = 0.82$).
Conclusions: Cardiac arrest occurring at night or during weekend hours is associated with a longer ECPR initiation time and higher rates of CNS injury. However, prolonged pre-ECPR support associated with off-hours cardiac arrest does not appear to impact survival or functional outcome in pediatric patients.

Introduction

The use of extracorporeal cardiopulmonary resuscitation (ECPR) is associated with improved survival when compared to conventional cardiopulmonary resuscitation for pediatric patients with refractory cardiac arrest.[1–4] To be effectively implemented, ECPR requires well-coordinated mobilization of hospital resources and personnel to achieve timely initiation of extracorporeal life support (ECLS). Although most large pediatric hospitals in North America maintain ECLS equipment and are capable of providing ECLS at any time, ECLS clinical specialists and surgeons capable of performing ECLS cannulation may not be immediately available at all times. In-hospital cardiac arrest occurring during nighttime and weekends is associated with worse survival than cardiac arrest occurring during weekdays[5–8] and pediatric intensive care unit admissions during the evening appear to be associated with worse survival than daytime admissions.[9] There is evidence that ECPR outcomes are worse during weekend cardiac arrest events in adult patients and that maintaining a 24/7 in-house surgical team may mitigate time/day of the week differences in survival.[10] Overall ECPR survival appears to be better in children than adults[11] and the impact of time of arrest on ECPR outcome has not been evaluated in pediatric patients. The aim of this study is to examine the impact of time of arrest on ECPR initiation time and survival in pediatric patients.

Methods

Retrospective demographic and clinical data was collected on all consecutive patients who received ECPR from December 2008 to August 2015 at Seattle Children's Hospital. Data analysis was limited to the initial ECPR event for patients who experienced multiple ECPR events during a single hospitalization (one patient

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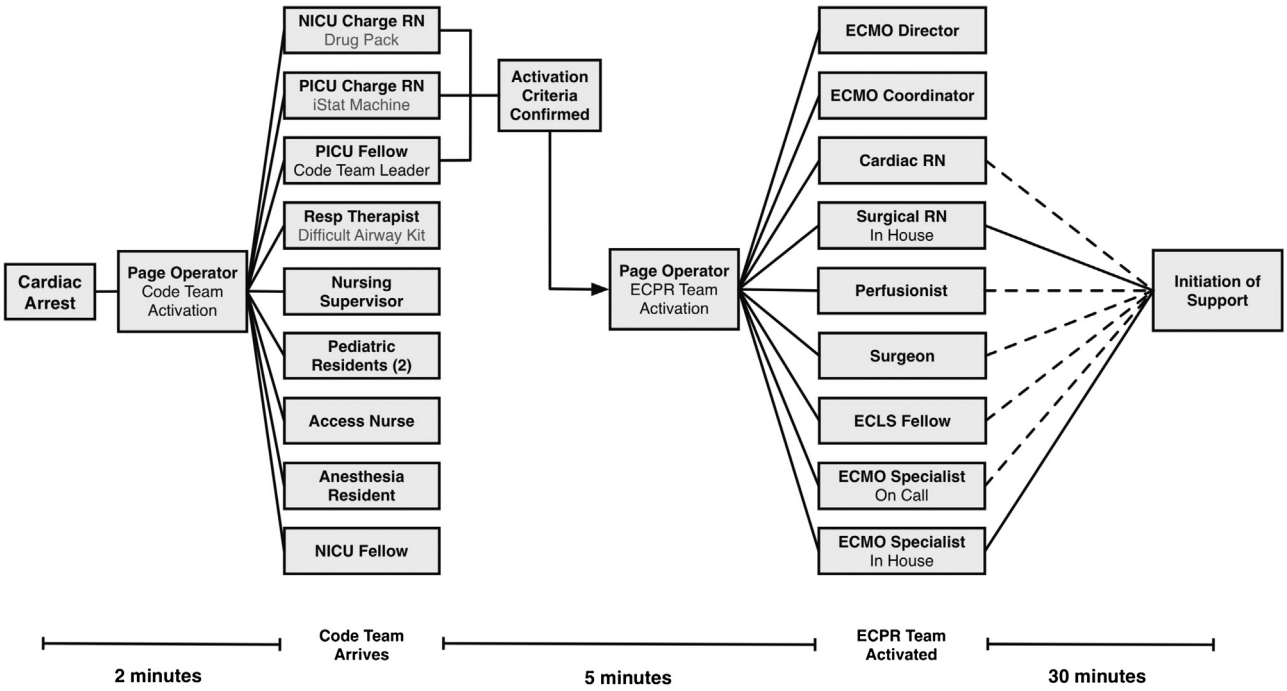

Fig. 1. Flow chart depicting our institutional cardiac arrest response and ECPR activation algorithm. Solid lines demarcate providers available in-house 24/7 while dashed lines represent those that are on call but not immediately available during nighttime and weekend hours.

Table 1
Patient characteristics.

Characteristic	Weekday (n = 20)	Night/weekend (n = 34)	Total (n = 54)	p-Value
Age (mos)	7.5 (2.3–18)	9 (2–72)	8.5 (2–36)	0.425
Male (%)	14 (70%)	18 (52.9%)	32 (59.3%)	0.262
Weight (kg)	6.3 (4.3–9.7)	6.9 (3.3–10.3)	6.4 (3.9–10.3)	0.713
Cardiac (%)	20 (100%)	22 (64.7%)	42 (77.8%)	0.002
Post-op (%)	15 (75%)	18 (52.9%)	33 (61.1%)	0.151
Pre-ECLS mechanical ventilation (%)	17 (85%)	28 (82.4%)	45 (83.3%)	1
Central cannulation (%)	6 (30.0%)	9 (26.5%)	15 (27.8%)	0.831
CICU (%)	17 (85%)	23 (67.7%)	40 (74.1%)	0.208

Abbreviations: CICU, cardiac intensive care unit; mos, months; kg, kilograms; Post-op, post-operative.

had two ECPR events during a single hospitalization). However, patients with multiple ECPR events during separate hospitalizations were included, with the index ECPR event during each admission included in the analysis. Patients who experienced return of spontaneous circulation prior to initiation of ECLS were excluded from analysis. ECPR events occurring in the operating room were excluded from this analysis. This study was approved by the Seattle Children's Hospital institutional review board and requirement for consent was waived.

A formal ECPR program was established at Seattle Children's Hospital in December of 2008. The primary ECPR team includes cardiac surgeons, perfusion specialists, intensive care specialists, and nursing and respiratory care ECLS specialists. All ECPR cannulations are performed by cardiac surgeons. The hospital does not maintain in-house surgical or perfusion coverage and these members of the team are typically not immediately available in-house during nighttime and weekend hours (Fig. 1). Weekday ECPR is defined as occurring Monday through Friday between the hours of 0600 and 1800. Night and weekend ECPR is defined as occurring from Friday at 1800 to Monday at 0600 and any day from 1800 to 0600. All neonatal ECLS patients receive routine cranial ultrasound during the course of extracorporeal support, whereas CT scanning or EEG analysis are only performed when suspicion for neurologic injury arises.

Complications occurring during ECLS were categorized based on categories established by the Extracorporeal Life Support Organization registry.[12] Mechanical complications included ECLS oxygenator failure, ECLS pump malfunction, heat exchanger malfunction, ECLS cannula malfunction, and circuit connector fracture. ECLS circuit thrombosis and circuit rupture tubing were analyzed separately. Other complications included: (1) neurologic injury, including clinical or electrographic evidence of seizures, radiographic evidence of CNS hemorrhage or infarction, and brain death; (2) acute kidney injury resulting in the need for renal replacement therapy (hemodialysis, continuous hemofiltration); (3) hemorrhage (surgical site, cannulation site, gastrointestinal, or pulmonary); (4) acidosis during ECLS (pH < 7.20); (5) cardiac failure (cardiopulmonary resuscitation while on ECLS); (6) blood stream infections; and (7) other complications that necessitated intervention (pneumothorax and cardiac dysrhythmia). ECLS initiation time was defined as the interval of time from ECPR activation to commencement of ECLS. ECLS response time was defined as the time interval from ECPR activation to initial incision for cannulation. Cannulation time was defined as the time interval from initial incision to commencement of ECLS. Functional outcomes were assessed using the pediatric cerebral performance categories (PCPC) score prior to initiation of ECLS, upon ICU discharge, and at one-year follow-up.[1,13,14] PCPC was developed as a reliable and