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Clinical paper

Incidence, characteristics, and survival following cardiopulmonary resuscitation in the quaternary neonatal intensive care unit☆

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ABSTRACT

Background: The contemporary characteristics and outcomes of cardiopulmonary resuscitation (CPR) in the neonatal intensive care unit (NICU) are poorly described. The objectives of this study were to determine the incidence, interventions, and outcomes of CPR in a quaternary referral NICU.
Methods: Retrospective observational study of infants who received chest compressions for resuscitation in the Children's Hospital of Philadelphia NICU between April 1, 2011 and June 30, 2015. Patient, event, and survival characteristics were abstracted from the medical record and the hospital-wide resuscitation database. The primary outcome was survival to hospital discharge. Univariable and multivariable analyses were performed to identify patient and event factors associated with survival to discharge.
Results: There were 1.2 CPR events per 1000 patient days. CPR was performed in 113 of 5046 (2.2%) infants admitted to the NICU during the study period. The median duration of chest compressions was 2 min (interquartile range 1, 6 min). Adrenaline was administered in 34 (30%) CPR events. Of 113 infants with at least one CPR event, 69 (61%) survived to hospital discharge. Factors independently associated with decreased survival to hospital discharge were inotrope treatment prior to CPR (adjusted Odds Ratio [aOR] 0.14, 95% Confidence Interval [CI] 0.04, 0.54), and adrenaline administration during CPR (aOR 0.14, 95% CI 0.04, 0.50).
Conclusions: Although it was not uncommon, the incidence of CPR was low (<3%) among infants hospitalized in a quaternary referral NICU. Infants receiving inotropic therapy prior to CPR and adrenaline administration during CPR were less likely to survive to hospital discharge.

Introduction

Little is known about the current practices and outcomes of cardiopulmonary resuscitation (CPR) in the neonatal intensive care unit (NICU). In historical studies, the reported incidence of CPR ranged from 1% to 6% of all infants admitted to the NICU,[1–3] and was as high as 10%–34% among extremely preterm infants.[4–7] Between 49% to 100% of infants who received CPR in these studies died before hospital discharge, prompting some authors to question whether CPR in extremely preterm infants in the NICU is futile.[4,6]

However, many of these studies are over 15 years old and may not reflect current trends in CPR practice or outcomes in newborns. In addition, many of these early reports only included extremely preterm infants who received CPR in the first days after birth.[2,5,6]

With growing survival of extremely preterm newborns, complications of prematurity that require management at referral NICUs are increasing in prevalence.[8] After surviving the initial neonatal periods with unstable fetal-neonatal transition and early neonatal cardiorespiratory disorders, these patients remain acutely ill throughout infancy and may suffer from acute cardiopulmonary instability requiring CPR. Characteristics and outcomes of CPR in the referral neonatal population are not well described. The objectives of this study were to determine the incidence, interventions,

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and outcomes of CPR events in a contemporary quaternary referral NICU.

Methods

Study design and population

This was a retrospective cohort study of all infants <1 year of age who received CPR (defined as chest compressions for resuscitation) between April 1, 2011 and June 30, 2015 in the Children's Hospital of Philadelphia (CHOP) NICU. This time period was selected because it encompasses the years when a hospital wide CPR database was in place. Delivery room CPR events were not captured in this database and were not evaluated in this analysis. The CHOP Institutional Review Board approved this study with a waiver of parental informed consent.

The CHOP NICU is a 96-bed level 4 referral NICU.[9] The most common reasons for admission are surgery (38%), respiratory management (16%), neurologic problems (9%), and congenital anomalies (7%). Infants with complex congenital heart disease are not typically managed in the CHOP NICU in the immediate perioperative period but may be transferred to the NICU once their acute cardiac problems resolve. Approximately half of admitted infants are preterm (<37 weeks gestation); 14% have a gestational age <29 weeks at birth, and 9% are of 29–33 weeks gestation at birth. At the time of admission, 42% of infants are greater than 2 weeks postnatal age. The baseline in-unit mortality is 5%.

All staff in the CHOP NICU are trained in the Neonatal Resuscitation Program (NRP) guidelines.[10] CPR is initiated in infants with a heart rate <60 beats per minute after attempting to establish effective positive pressure ventilation. Chest compressions are performed with a backboard in place and are coordinated with ventilation in a 3:1 ratio.

Data sources

Infants were identified from a hospital-wide resuscitation database that captures all acute events for which the NICU emergency (code) alarm is activated. Per unit policy, a dedicated staff member records pre-specified data in real time into a resuscitation record during the resuscitation event. Basic demographic, resuscitation, and outcome data are subsequently entered into the resuscitation database (Supplemental file). We independently confirmed all resuscitation events using the infant's primary medical record and abstracted detailed information about the resuscitation from the resuscitation database. Additional pre-specified demographic, medication, and laboratory data was abstracted from the medical record. We used administrative data to determine the baseline number of NICU admissions and patient days during the study period.

Study definitions and outcomes

CPR was defined as any event for which chest compressions were performed. If an infant had more than one CPR resuscitation event during his/her hospital admission, only the first event was included in this analysis. CPR events were sub-classified as either acute respiratory compromise (ARC) preceding cardiopulmonary arrest (CPA), or CPA alone, according to American Heart Association definitions.[11] Briefly, ARC is defined as activation of a unit-based emergency response for absent, agonal or inadequate respiration that requires emergency assisted ventilation. CPA is defined as a cardiopulmonary resuscitation event requiring chest compressions and/or defibrillation.

The duration of chest compressions, inclusive of pauses for pulse checks or other interventions, was abstracted from the resuscitation record and recorded in whole minutes. Medications administered during the resuscitation were abstracted from the resuscitation record. Medications given prior to CPR were classified as any medication administered during the 24 h prior to the event, as documented in the electronic medical record. Continuous capnography monitoring of intubated patients is not routinely used in the CHOP NICU, and monitoring tools such as arterial line waveforms during CPR were not recorded in the database.

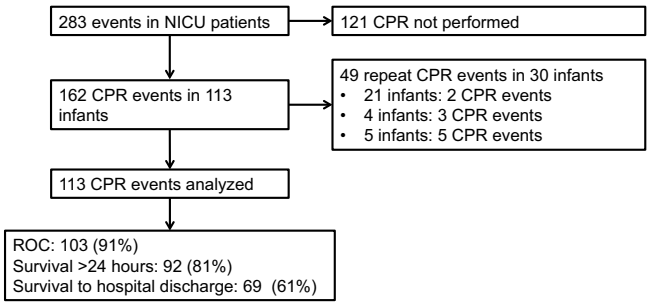

Fig. 1. Flow diagram of CPR events included in the analysis.

The primary study outcome was survival to hospital discharge. Secondary outcomes were return of circulation (ROC), defined as no further need for chest compression within 20 min of the event, and survival for >24 h after CPR.

Data analysis

Descriptive summary statistics were generated for the interventions performed during resuscitation and the baseline characteristics and outcomes of infants who received CPR. We examined the association between in-hospital mortality and the following covariates: gestational age, post-natal age at event, primary diagnosis, inotropes prior to CPR (as an indicator of hypotension), systemic antibiotics prior to CPR (as an indicator for proven or suspected sepsis), primary CPA event, duration of chest compressions, and administration of adrenaline (epinephrine) during CPR. These potential risk factors were a priori selected because they were reported to be associated with mortality in previous studies of neonates or older children or were hypothesized to be significant contributors to in-hospital mortality in our population.[5,12,13] We explored the associations between these covariates and the study outcomes using chi-square or Fisher's exact tests for dichotomous variables and Wilcoxon rank sum tests for continuous variables. A p-value < 0.05 was considered statistically significant.

We used stepwise backwards logistic regression to identify patient and resuscitation characteristics that were independently associated with survival to hospital discharge. Variables associated with the primary outcome at $p < 0.1$ in univariate analysis were included in the initial model. We then sequentially removed each variable from the model, using the likelihood ratio test to identify the most parsimonious model. We analyzed the data using Stata 14.0 (Statacorp, College Station, TX).

Results

Infant characteristics and CPR events

During the study period 5046 infants were admitted to the CHOP NICU. There were 162 CPR events in 113 infants, representing 2.2% of infants admitted during the study period. Thirty infants had more than one CPR event (Fig. 1). There were 1.2 CPR events per 1000 patient days.

Study infants had a median gestational age of 28 weeks, median birth weight of 950 g, and median chronological age of 11 weeks at