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Cardiopulmonary Resuscitation for Bradycardia With Poor Perfusion Versus Pulseless Cardiac Arrest

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KEY WORDS

cardiac arrest, CPR, bradycardia, Pediatric Advanced Life Support

ABBREVIATIONS

CPR—cardiopulmonary resuscitation
PALS—Pediatric Advanced Life Support
NRCPR—National Registry of Cardiopulmonary Resuscitation
ROSC—return of spontaneous circulation
PEA—pulseless electrical activity

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WHAT'S KNOWN ON THIS SUBJECT: CPR is recommended for children with bradycardia and poor perfusion. No controlled analysis has attempted to account for difference in outcomes between children who receive CPR for bradycardia as opposed to pulselessness.

WHAT THIS STUDY ADDS: This study's results support the current PALS recommendations that children with bradycardia and hypoperfusion receive CPR and that outcomes are improved with respect to patients who receive CPR for a pulseless state.

abstract

OBJECTIVE: The objective of this study was to assess whether pediatric inpatients who receive cardiopulmonary resuscitation (CPR) for bradycardia with poor perfusion are more likely to survive to hospital discharge than pediatric inpatients who receive CPR for pulseless arrest (asystole/pulseless electrical activity [PEA]), after controlling for confounding characteristics.

METHODS: A prospective cohort from the National Registry of Cardiopulmonary Resuscitation was enrolled between January 4, 2000, and February 23, 2008. Patients who were younger than 18 years and had an in-hospital event that required chest compressions for $>$2 minutes were eligible. Patients were divided into 2 groups on the basis of initial rhythm and pulse state: bradycardia/poor perfusion and asystole/PEA. Patient characteristics, event characteristics, and clinical characteristics were analyzed as possible confounders. Univariate analysis between bradycardia and asystole/PEA patient groups was performed. Multivariable logistic regression was used to determine whether an initial state of bradycardia/poor perfusion was independently associated with survival to discharge.

RESULTS: A total of 6288 patients who were younger than 18 years were reported; 3342 met all inclusion criteria. A total of 1853 (55%) patients received chest compressions for bradycardia/poor perfusion compared with 1489 (45%) for asystole/PEA. Overall, 755 (40.7%) of 1353 patients with bradycardia survived to hospital discharge, compared with 365 (24.5%) of 1489 patients with asystole/PEA. After controlling for known confounders, CPR for bradycardia with poor perfusion was associated with increased survival to hospital discharge.

CONCLUSIONS: Pediatric inpatients with chest compressions initiated for bradycardia and poor perfusion before onset of pulselessness were more likely to survive to discharge than pediatric inpatients with chest compressions initiated for asystole or PEA. *Pediatrics* 2009;124:000

Cardiopulmonary resuscitation (CPR) for cardiac arrest is provided for ~1% to 2% of PICU patients in North America.[1,2] Only 27% of these children with in-hospital cardiac arrests survive to hospital discharge.[3] The immediate causes of most of these cardiac arrests are progressive respiratory failure and circulatory shock.

Infants and children with progressive respiratory failure and shock typically have bradycardia with a pulse before the development of pulseless arrest with either pulseless electrical activity or asystole.[4] The American Heart Association Pediatric Advanced Life Support (PALS) guidelines recommend provision of chest compressions and ventilation to children when bradycardia with poor perfusion persists despite adequate oxygenation and ventilation[5]; however, provision of chest compressions while a child has a perfusing rhythm can create atrioventricular dyssynchrony and may worsen hemodynamics.[6] To date, no controlled studies have examined the effect of chest compressions on survival outcomes for pediatric cardiac arrest victims who present with bradycardia and poor perfusion before the onset of pulselessness.

The aim of this study was to evaluate whether children who receive in-hospital CPR for bradycardia with pulses and poor perfusion have improved survival compared with children who receive CPR for an initial presentation of pulseless arrest, after controlling for patient, event, and clinical variables, as well as processes of care during the resuscitation events. The study was conducted using the National Registry of Cardiopulmonary Resuscitation (NRCPR), a large multihospital database of in-hospital cardiac arrest events. We hypothesized that children who received CPR for a first documented rhythm of bradycardia with pulses would be more likely to survive to hospital discharge compared with children who received CPR for an initial presentation of documented nonshockable pulseless cardiac arrest (asystole or pulseless electrical activity).

METHODS

The NRCPR is an American Heart Association–sponsored prospective multisite registry of patients who undergo in-hospital resuscitation. Hospitals voluntarily participate in the database for the primary purpose of quality improvement and as such are not required to obtain institutional review board approval or informed consent from patients or families. This study was exempted from institutional review board oversight.

Inclusion and Exclusion Criteria

Data were analyzed from all 242 hospitals that provided data for at least 6 months during the study period from January 2000 to February 2008. All patients who were younger than 18 years and sustained a clinical event that required chest compressions for >2 minutes at a participating hospital were eligible for inclusion. According to NRCPR operational definitions, a CPR event includes any event characterized by either pulselessness or critically compromised perfusion treated with external chest compressions, when a unit-wide or hospital-wide emergency response was activated. Events that commence out-of-hospital and events in newborn infants in the delivery suite are excluded. For the purpose of this study, the prospectively determined outcome of interest was survival to hospital discharge. Secondary outcomes included return of spontaneous circulation (ROSC) and 24-hour survival.

Statistical Analysis

All statistical analyses used commercially available statistical packages (Statistical Applications Software 9.1 [SAS Institute, Cary, NC] and R, the R Foundation for Statistical Computing 2.6.0).

Treatment of Missing Data

Missing data patterns were examined for all fields by stratifying the "missing" category by the primary exposure variable. Within-group percentages of missing values did not vary substantially from each other for any of the data fields. Events with a missing survival to discharge indicator and events for which we could not determine the appropriate primary exposure group were excluded from all analyses. Missing data values for all other covariates were coded as "unknown" or "none."

Descriptive Statistics

Differences between binary survival outcome groups with respect to several potential risk factors were characterized. χ^2 testing was used for discrete variables, and Wilcoxon rank-sum testing was used for continuous variables. All P values represent 2-sided hypothesis tests. The significance level for all tests was $\alpha = .05$.

Event duration was defined as the time interval from the delivery of the first chest compression until either the time of sustained ROSC (lasting >20 minutes) or the time when resuscitation efforts were terminated. The continuous variable of event duration was collapsed to a nominal variable via LOWESS curve generation, on the basis of a logistic regression model that incorporates smoothing splines. Daytime events were defined to be those that occurred between 7:00 AM and 10:59 PM and weekend as 5:00 PM Friday to 6:59 AM Monday. Respiratory support was defined as the presence of ≥1 of the following: assisted ventilation, mechanical ventilation, or inhaled nitric oxide. Cardiovascular support was defined as the presence of ≥1 of the following: any vasoactive infusion, any antiarrhythmic infusion, a pulmonary artery catheter, or an intra-aortic balloon pump.

Multivariable Analysis

Multivariable logistic regression models were used to examine the effect of our primary exposure group on survival outcomes. These models were fit as generalized estimating equations to account adequately for within-facility correlation. Prospectively designated clinically important potential confounders or their class (age, gender, race, illness category, event location, combination of preexisting condition and cause variables, interventions in place at time of event, monitored status, witnessed status, event duration, use of epinephrine, use of vasopressin, ventricular fibrillation or pulseless ventricular tachycardia at any time during the event, time from hospital admission to event, time of day [day/evening versus night] the event occurred, and whether the event occurred during a weekend) were included as candidate predictors in the models. For each outcome, a final multivariable model was fit to include the covariates determined to be significant at $\alpha = .10$ in the initial model. Age, gender, and race were included in all final models.

Data Integrity

Data integrity was maintained by using a detailed periodic reabstraction process. NRCPR participating hospitals submitted randomly selected records each quarter, and a random sampling of event records and corresponding NRCPR data sheets were reabstracted and reviewed for errors by NRCPR Scientific Advisory Board members. Mean ± SD error rates for all data were 2.5% ± 2.7%. Web-based remediation was used to support data integrity continuously for enrolling sites. Enrollment of new hospitals as contributors to the database requires certification by testing accuracy of data collection before allowing data submission centrally.

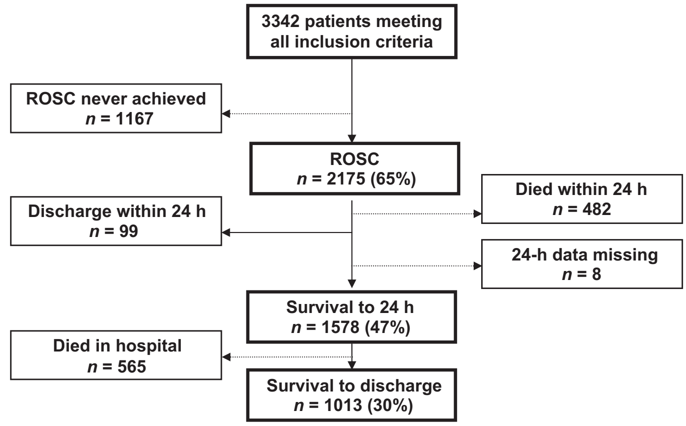

FIGURE 1
Utstein outcome diagram (entire data set).

RESULTS

During the study period, 130 772 consecutive cardiac arrests were reported; 6288 (4.8%) occurred in patients who were younger than 18 years. Within this pediatric cohort, 1219 (19%) events were excluded as nonindex events, 692 (11%) events were excluded from analysis on the basis of a CPR duration of <2 minutes, 310 (5%) events were excluded because they were events in the delivery room, and 54 (<1%) were excluded because of missing data. Of the remaining 4259 events, 917 (22%) were excluded because the first documented rhythm was shockable (12%) or unknown (10%); therefore, a total of 3342 patients were included in the final analysis (Fig 1). Among the 242 hospitals that contributed data, 16 (7%) were pediatric facilities, 171 (70%) were mixed facilities, and 55 (23%) were adult facilities. A total of 1464 (44%) of these index cardiac arrests occurred in pediatric facilities. The median size of the contributing hospitals was 362 beds (range: 80–1300); the median number of beds that were dedicated to pediatric inpatient care (ward and ICU) was 17 (range: 0–323).

Patient and event characteristics for the cardiac arrest victims who presented with bradycardia with poor perfusion versus pulseless arrest (asystole/pulseless electrical activity [PEA]) are shown in Table 1. A significantly greater proportion of neonates received compressions that were initiated for bradycardia with poor perfusion, whereas children who were older than 1 year commonly presented with asystole or PEA at the time that compressions were initiated. A significantly increased prevalence of chest compressions were initiated for bradycardia with poor perfusion in ICU patients compared with other locations and during day or evening hours compared with nighttime. Interventions that were in place before the event, immediate cause of the event, and clinical interventions that used during the event for both groups are shown in Table 2.

Clinical outcomes are presented in Fig 1. ROSC was achieved by 65% of the study cohort, 24-hour survival by 47%, and survival to hospital discharge by 30%. Outcomes by patient group are shown in Fig 2. By unadjusted univariate analysis, patients whose CPR was initiated for bradycardia with pulses and poor perfusion had improved survival for all outcomes ($P < .001$). Outcomes by patient group stratified by age category are shown in Table 3. By

TABLE 1 Patient and Event Characteristics and Association With Patient Group

Characteristic	Bradycardia/Poor Perfusion ($N = 1853$)	Asystole/PEA ($N = 1489$)	P[a]
Age, y			
Mean	1.89	4.80	<.0001
Median	0.19	1.30	<.0001
Age category, *n* (%)			<.0001
Newborn	738 (40)	301 (20)	
<1 y	648 (35)	398 (27)	
1 to <8 y	288 (16)	366 (25)	
≥8 y	179 (10)	424 (28)	
Male, *n* (%)	1031 (56)	842 (56)	.600
Race			.050
White	946 (51)	813 (55)	
Black	462 (25)	367 (25)	
Hispanic	353 (19)	217 (14)	
Unknown	92 (5)	92 (6)	
Illness category, *n* (%)			<.0001
Medical, cardiac	242 (13)	210 (14)	
Medical, noncardiac	676 (36)	623 (42)	
Surgical, cardiac	290 (16)	237 (16)	
Surgical, noncardiac	134 (7)	119 (8)	
Trauma	77 (4)	177 (12)	
Newborn	420 (23)	112 (8)	
Other	14 (0.7)	11 (0.7)	
Location, *n* (%)			<.0001
ICU	1509 (81)	943 (63)	
Emergency department	95 (5)	264 (18)	
General inpatient	95 (5)	149 (10)	
Diagnostic/interventional area	40 (2)	31 (2)	
Operating room or PACU	55 (3)	51 (3)	
Other	41 (2)	42 (3)	
Witnessed event, *n* (%)	1766 (95)	1333 (90)	<.0001
Monitored, *n* (%)	1788 (96)	1270 (85)	<.0001
Time from hospital admission to event, *n* (%)			<.0001
First quartile (0 d)	551 (30)	634 (43)	
Second quartile (≤2 d)	374 (20)	271 (18)	
Third quartile (≤12 d)	432 (23)	277 (19)	
Fourth quartile (>12 d)	496 (27)	307 (21)	
Day, *n* (%)	1328 (72)	1011 (68)	.020
Weekday, *n* (%)	1282 (69)	1009 (68)	.380

PACU indicates postanesthesia care unit.

[a] χ^2 analysis, bradycardia group versus asystole/PEA group.

unadjusted univariate analysis, newborns, infants, and children who were younger than 8 years and received CPR that was initiated for bradycardia with pulses and poor perfusion had improved survival to discharge; no difference was observed for children who were older than 8 years.

Among patients who received CPR for an initial state of bradycardia with pulses and poor perfusion, Utstein outcomes are broken down by their subsequent rhythm states in Fig 3. A total of 84% of these patients received at least 1 bolus of epinephrine or vasopressin, suggesting that they were clinically judged to have cardiac arrest physiology. The majority (63%) of these patients never became pulseless. By unadjusted univariate analysis, clinical outcomes among patients who progressed to a pulseless state after CPR was initiated for bradycardia with poor perfusion were worse than those who never became pulseless ($P <$ .0001) as well as those who had CPR initiated for an initial state of asystole or PEA ($P =$ .02).

Although patients with a first documented shockable rhythm were excluded from analyses, 305 (10%) patients with initial bradycardia or asystole/PEA developed either ventricular fibrillation (VF) or pulseless ventricular tachycardia (VT) at some point during the resuscitation (ie, subsequent VF/VT). This occurred in 118 (6%) of 1853 patients who presented with bradycardia and 187 (13%) of 1489 of the patients who presented with asystole/PEA ($P <$ .0001). Overall survival to discharge among these patients with subsequent VF/VT was 43 of (14%) 305 compared with 1077 (35.5%) of 3037 among patients who never developed subsequent VF/VT ($P <$ .0001). Among patients with subsequent VF/VT, survival to discharge rates were significantly greater for patients who presented with bradycardia and poor perfusion (22 [18%] of 118) versus patients who presented with asystole/PEA (13 of 185 [7%]; $P =$ .005).

Multivariable analysis results are presented in Table 4; all factors that were independently associated with survival to discharge are displayed. Initiation of CPR for bradycardia with pulse and poor perfusion remained significantly associated with survival to discharge (adjusted odds ratio: 1.57 [95% confidence interval: 1.29–1.90]). It should be noted that several factors with significant univariate association with patient group (eg, witnessed arrest, monitored status, daytime hours) were not significantly univariately associated with outcomes and as such were not included in the multivariate model.

DISCUSSION

These data establish that children who received chest compressions for bradycardia with pulses and poor perfusion before the onset of pulselessness were more likely to survive to hospital discharge compared with children who received chest compressions for pulselessness (asystole/PEA). This difference persisted after controlling for potential confounders related to pa-

TABLE 2 Clinical Characteristics and Association With Patient Group

Characteristic	Bradycardia/Poor Perfusion ($N = 1853$), n (%)	Asystole/PEA ($N = 1489$), n (%)	P[a]
Preevent interventions			
Respiratory support	1321 (71)	891 (60)	<.0001
Cardiovascular support	659 (36)	538 (36)	.7300
Immediate cause			<.0001
Cardiac	358 (19)	415 (29)	
Respiratory	411 (22)	197 (13)	
Mixed	565 (30)	410 (28)	
Other/unknown	519 (28)	467 (31)	
Resuscitative interventions			
Invasive airway	1726 (93)	1434 (96)	<.0001
Epinephrine	1455 (79)	1347 (90)	<.0001
Vasopressin	39 (2)	57 (4)	.0030
Event duration			<.0001
0–15 min	931 (50)	565 (38)	
15–35 min	518 (28)	502 (34)	
>35 min	388 (21)	419 (28)	
Subsequent VF/PVT (%)	118 (6)	187 (13)	<.0001

[a] χ^2 analysis, bradycardia group versus asystole/PEA group.

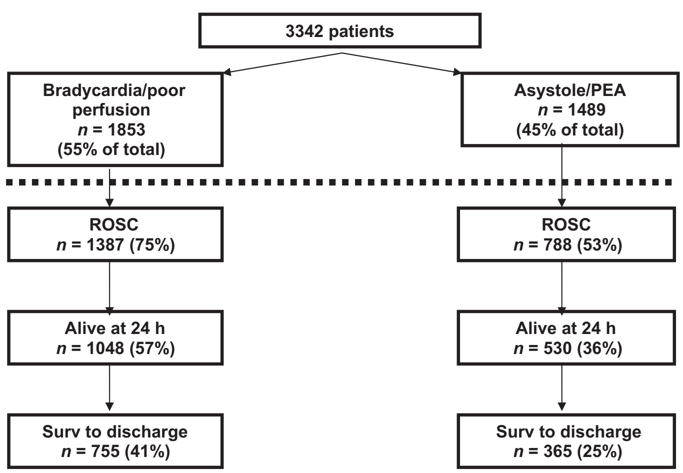

FIGURE 2
Utstein outcome diagram, according to patient group.

TABLE 3 Survival to Discharge Stratified According to Age Group

Age Category	Bradycardia/Poor Perfusion, n/N (%)	Asystole/PEA, n/N (%)	P[a]
Newborn	262/738 (36)	77/301 (26)	.0020
Infant	336/648 (52)	131/398 (33)	<.0001
Child (aged >1 to <8 y)	118/288 (41)	84/366 (23)	<.0001
Older child (aged ≥8 y)	39/179 (22)	73/424 (17)	.1870

[a] χ^2 analysis, bradycardia group versus asystole/PEA group.

tient characteristics, event characteristics, and clinical interventions during the event. These findings support current PALS recommendations to initiate chest compressions for conditions of bradycardia with poor perfusion and allay concerns that delivery of chest compressions during a perfusing rhythm are dangerous because of potential atrioventricular dyssynchrony.[6]

It has long been recognized in young children that increased heart rate is the predominant mechanism for augmenting cardiac output, whereas increased stroke volume is a lesser contributor.[7] Consequently, symptomatic bradycardia typically is associated with a very low cardiac output. In neonates, bradycardia is known to be a physiologic consequence of acidosis and hypoxia. The Neonatal Resuscitation Program guidelines have focused on the restoration of oxygenation and ventilation before initiating chest compressions for bradycardia and then recommend chest compressions for persistent bradycardia of <60 beats per minute. Data published by Walsh and Krongrad[4] in terminally ill children, including those beyond the neonatal age range, demonstrated that bradycardia is a typical rhythm that occurs before the onset of pulselessness. Animal models of asphyxia have also demonstrated a typical progression of bradycardia and hypoperfusion leading to PEA and/or asystole[8]; these studies also demonstrated that CPR can be successful in the earlier stage of this continuum.[9,10]

The immediate causes of most in-hospital cardiac arrests in children are progressive respiratory and/or circulatory insufficiency.[3] Consequently, ~90% of in-hospital pulseless cardiac arrests in children have a first documented rhythm of asystole or PEA. It is desirable, therefore, to clarify the potential contribution to improved survival outcomes from CPR that is initiated for bradycardia before progression to a pulseless cardiac arrest. Patients with shockable rhythms at the time of their event were excluded from analysis with this in mind.

It is only in recent multihospital analyses that the substantial prevalence of CPR administration for bradycardia without pulselessness in children has been described. In a single-center, prospective cohort, Reis et al[11] reported that 33% of children who were younger than 18 years and receiving in-hospital

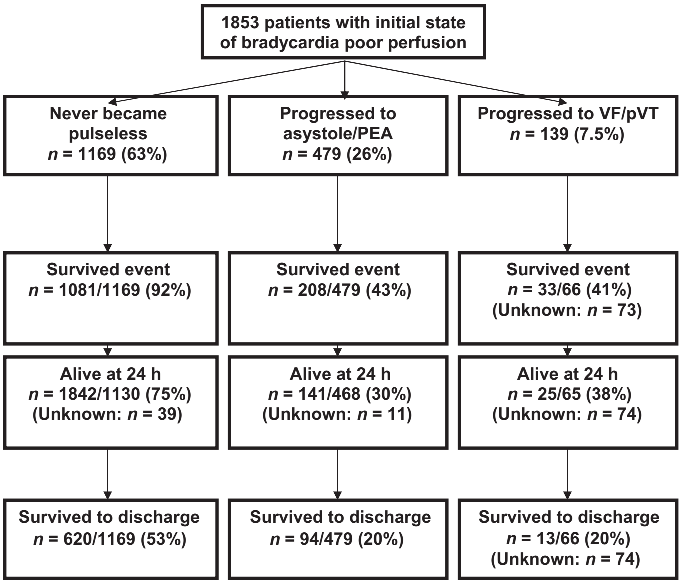

FIGURE 3
Outcomes of patients with bradycardia/poor perfusion according to subsequent rhythm (Utstein diagram).

TABLE 4 Multivariable Analysis

Factor	*P*	OR (95% CI) for Survival to Discharge
Male gender	.7980	0.98 (0.81–1.18)
Age category (vs >8 y)		
<1 mo	.3504	1.22 (0.81–1.85)
1–12 mo	.0010	2.02 (1.33–3.07)
1–8 y	.0092	1.56 (1.12–2.18)
Illness category (vs surgical, noncardiac)		
Medical, cardiac	.7556	0.94 (0.63–1.40)
Medical, noncardiac	.1671	0.76 (0.52–1.12)
Surgical, cardiac	.0028	2.09 (1.29–3.37)
Trauma	<.0001	0.33 (0.21–0.52)
Newborn	.0409	0.60 (0.37–0.98)
Other/unknown	.9874	1.00 (0.47–2.14)
Event location vs inpatient ward)		
Emergency department	.1215	0.72 (0.47–1.09)
ICU	.7416	1.07 (0.71–1.61)
Operating room/PACU	<.0001	3.84 (1.99–7.41)
Diagnostic/interventional area	.0003	2.73 (1.59–4.68)
Outpatient	.0788	1.48 (0.96–2.30)
Unknown	.0254	2.95 (1.14–7.62)
Prearrest interventions		
Respiratory support	.0011	0.61 (0.45–0.82)
Cardiovascular support	<.0001	0.43 (0.32–0.57)
Immediate cause (vs cardiac)		
Respiratory	<.0001	2.20 (1.70–2.86)
Mixed	.0172	1.28 (1.05–1.57)
Other/unknown	.4387	0.91 (0.71–1.16)
Resuscitative interventions		
Epinephrine	<.0001	0.27 (0.21–0.34)
Vasopressin	.0457	0.45 (0.21–0.99)
Event duration (vs <15 min)		
15 to <35 min	<.0001	0.37 (0.30–0.45)
>35 min	<.0001	0.21 (0.16–0.27)
Subsequent VF/PVT	.0010	0.54 (0.37–0.78)
Bradycardia with pulse (vs asystole/PEA)	<.0001	1.57 (1.29–1.90)

OR indicates odds ratio; CI, confidence; PACU, postanesthesia care unit.

CPR were in an initial state of bradycardia with poor perfusion, and the presence of a pulse was independently associated with 24-hour survival. In an previous investigation of the NRCPR that excluded neonates, Nadkarni et al[3] found that 18% of pediatric inpatients who received CPR had bradycardia without pulselessness, in contrast to 2% of adults. Univariate analysis suggested that children who presented with bradycardia were more likely to survive to discharge than children who received CPR for pulseless rhythms. In a study of exclusively pediatric patients from the NRCPR, Donoghue et al[12] found that CPR was initiated for bradycardia with poor perfusion in 42% of patients but was not independently associated with survival; these findings led to this study. Our study shows that providers commonly initiate chest compressions for children before pulselessness. When initial shockable rhythms are excluded, 55% of the patients received CPR for bradycardia with pulses. In addition, a greater proportion of neonates received CPR for bradycardia than did older children. The mean age of 3.2 years for patients in our cohort is significantly younger than in the studies Nadkarni et al[3] and Donoghue et al[12] (5.6 years and 4.0 years, respectively), and the greater prevalence of CPR for bradycardia in our study is likely attributable to a larger percentage of neonates, among whom CPR for bradycardia has been recommended by the Neonatal Resuscitation Program for some time. This also makes the explicit inclusion of this patient group in our multivariate model necessary, and while controlling for both the neonatal age range as well as the "newborn" diagnostic category, the association of CPR for bradycardia with poor perfusion remains significantly associated with survival. It is noteworthy, however, that a significant proportion of children in all age ranges, including a majority of infants, received CPR initiated for bradycardia with pulses, and that this was associated with survival in older children as well as neonates.

Differences in survival for cardiac surgery patients and trauma patients were similar to those found in previous NRCPR analyses and other studies.[3,12–14] Cardiac arrest after congenital heart surgery is usually an acute event in a patient with a single organ disease exacerbated by surgical trauma and an acute reversible post-cardiopulmonary bypass myocardial dysfunction. In addition, some resuscitative interventions that are especially applicable postoperatively for children in cardiac ICUs, such as extracorporeal circulatory support, presumably contribute to improved outcomes among cardiac surgical patients compared with other illness categories.[15,16] Outcomes from cardiac arrest associated with pediatric trauma have generally been dismal in previously reported studies; however, most published studies that examined this phenomenon dealt with out-of-hospital cardiac arrests.[17–19] Previous analyses of pediatric data from the NRCPR have demonstrated an independent association between trauma-related diagnosis and mortality.[3,12]

The larger cohort in this study provided adequate power to establish that initiation of CPR for bradycardia and poor perfusion with pulses was associated with improved outcomes, even after controlling for potential confounding clinical, event, and patient factors. Although this study design cannot prove a causal relationship and unknown confounders that were not accounted for in our analysis may exist, these data lend support to current PALS recommendations that CPR be initiated for bradycardia and poor perfusion despite adequate oxygenation and ventilation.[5]

The most important limitation to our study is that the NRCPR database includes only patients who received chest compressions. The ideal study design to evaluate the effect of CPR initiated for bradycardia with poor perfusion would be a comparison of outcomes among children who had bradycardia and received CPR versus those who did not. The inclusion criteria for the NRCPR database do not permit such a comparison. Nevertheless, we believe that our data provide new insights regarding the early provision of CPR in the most common pathophysiologic pathway for cardiac arrest in children (progression from bradycardia with hypoperfusion to a pulseless arrest with PEA and/or asystole).

Among the 1853 patients whose CPR was initiated for bradycardia with poor perfusion and duration of CPR $>$2 minutes, 1169 (63%) achieved ROSC without ever becoming pulseless. It is difficult to determine the contribution of chest compressions to these relatively favorable outcomes; the possibility exists that some of these patients would have survived if their resuscitative efforts did not include chest compressions. We attempted to mitigate this issue by including only children who received chest compressions for $\geq$2 minutes. We believe that it is unlikely that such children would have survived without chest compressions. In addition, that 84% of patients received at least 1 bolus of epinephrine or vasopressin suggests that their perfusion was critically compromised and advanced life support was needed.

The NRCPR is a multicenter registry with strict operational definitions and rigorous quality assurance. Nonetheless, the issues of data integrity and validity at the level of individual sites must always be considered as a potential limitation in interpreting data from such analyses. Also, only a finite set of hospitals are contributors to the NRCPR, representing a convenience sample of facilities that volunteer to become enrolling centers. Generalization of conclusions from our analysis to all centers may be limited.

CONCLUSIONS

In this large multihospital cohort, children who received CPR for bradycardia with pulses and poor perfusion were more likely to survive to hospital discharge than children who received CPR for pulseless arrest associated with asystole or PEA. These data provide support for the PALS recommendations to initiate chest compressions for the pediatric patient when bradycardia and poor perfusion persist despite adequate oxygenation and ventilation, before progression to a pulseless cardiac arrest. Future studies should attempt to clarify the specific contribution of chest compressions to outcomes in children with impending and existing cardiac arrest.

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