Epidemiology and outcome of pediatric in-hospital cardiopulmonary resuscitation in Northern India

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Abstract. Data regarding in-hospital pediatric cardiopulmonary resuscitation (CPR) are limited because of retrospective study designs and inconsistent definitions. There are no Indian studies on pediatric CPR. Accordingly, we conducted this retrospective study to determine the outcome of in-hospital CPR and assess which variables predict outcome. Consecutive in-hospital CPR events in children aged 1-mo to 14-yr during a 1 yr period were described prospectively using Utstein guidelines. Variables affecting outcome were evaluated by univariate and multivariate analysis. A total of 427 patients were enrolled and received CPR. The indication for CPR was primary respiratory failure in 213 (50%) and clinical cardiac arrest in 191 (44%). The most common underlying etiology was neurological illness (26%). Sustained return of spontaneous circulation was attained in 112 (26%). Fifty-three (12%) patients were alive at 24 h, of which only 8 (1.87%) were alive at discharge. Of those patients who survived to discharge, all were alive after 6 mo. Multivariate logistic regression analysis showed that CPR during night hours (adjusted odds ratio [aOR]: 3.73), CPR of more than 10 min duration (aOR: 27.04) and cardiac arrest as an indication of CPR (aOR: 2.56) were independently associated with poor immediate outcome. Factors associated with death within 24 h were CPR during night hours (aOR: 3.17), age > 1 yr (aOR: 5.52) and cardiac arrest (aOR: 4.93). Good neurological outcome was found in seven out of eight (87.5%) patients at follow up. We conclude that pediatric cardiac arrest in a tertiary hospital in India has a poor outcome even after survival beyond 24 h; however, neurological outcome is generally good among survivors.

Keywords: Cardiopulmonary resuscitation, in hospital, Utstein guidelines

1. Introduction

Cardiopulmonary resuscitation (CPR) is a desperate lifesaving effort to restore circulation and respiration within a few minutes in a patient or otherwise healthy individual who has suffered cardio-respiratory arrest from a catastrophic event [1]. In-hospital cardiopulmonary arrest is an emergency that requires teamwork and appropriate sequential action to rescue patients [2]. Data regarding pediatric in-hospital CPR have been limited

and difficult to interpret, as nearly all of the reported studies are retrospective studies involving small numbers of children. Moreover, definitions of cardiac arrest and CPR interventions have been inconsistent [3–7]. To address these problems, participants at a June 1990 International Resuscitation Conference concerned with out-of-hospital cardiac arrest research, held at the Utstein Abbey in Norway, met to develop consensus on standardized nomenclature and language in research reports. Unfortunately, the original Utstein style guidelines did not apply to pediatric resuscitation research because the focus of the guidelines was limited to out-of-hospital cardiac arrest in adults. Later, a task force was formed to formulate guidelines for pediatric resuscitation [5].

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In India, little data are available about survival after CPR in adults and data on pediatric CPR is almost non-existent. As outcome after CPR and the predictors of successful outcome are likely to be very different in the Indian context, extrapolation of the western experience to Indian practice is not appropriate. We therefore launched a prospective study on outcome of in-hospital CPR in children and factors influencing this in our hospital.

2. Materials and methods

A prospective observational cohort study was carried out at the pediatric emergency room, pediatric wards and pediatric intensive care unit of King George's Medical University Hospital, Lucknow, India over a period of 1 yr. This is a state run tertiary care teaching hospital in northern India. It caters to the poor and very sick children from Lucknow and the surrounding districts. Lucknow is the capital city of Uttar Pradesh, India's most populous state and is also one of its poorest with low human developmental indices.

Ethical approval for this study was obtained from the Ethics Committee of King George Medical University, Lucknow. Consecutive children aged 1-month-old to 14-year-old who received in-hospital CPR from August 2011 to July 2012 were included and followed for 6 mo. Patients in whom CPR was initiated in the prehospital

setting were excluded from analysis. Furthermore, patients who received only resuscitation drugs or positive pressure ventilation without the need of chest compression were also excluded. Pediatric residents and nurses provided CPR and all efforts were made to adhere to the American Heart Association 2010 pediatric CPR guidelines, which were distributed among resident doctors [8]. Some of pediatric residents had completed training in the American Heart Association Pediatric Advanced Life Support Course.

The data collection form was adapted from the in-hospital Utstein-style guidelines (Fig. 1). Three sets of variables were recorded: (a) Patient related variables (age, gender, weight, height, residence, nutritional status, underlying etiology); (b) Event related variables (location of CPR, duration of hospital stay prior to arrest, associated co-morbidities, indications of CPR, time and duration of CPR, therapeutic interventions including provision of adrenaline along with number of doses and provision of calcium and sodium-bicarbonate); (c) Outcome variables (return of spontaneous circulation [ROSC] including the duration, return of spontaneous ventilation [ROSV], immediate death, survival beyond 24-h, survival to hospital discharge, survival at 1, 3 and 6 mo follow up, and neurological outcome after hospital discharge). Lack of return of spontaneous circulation in effect means immediate death. Patient and event related data and outcome variables, such as ROSC and ROSV were recorded immediately after the event by a member

Fig. 1. Pediatric Utstein style template for recording outcome from in-hospital cardiopulmonary arrest.

of the resuscitating team on predesigned data collection forms. Day and night were arbitrarily defined 6 AM to 10 PM as day and 10 PM to 6 AM as night. This applied to weekends also.

The discharged patients were followed at 1, 3 and 6 mo. Neurological outcome was determined by using pediatric cerebral performance category (PCPC) scales [9]. A good neurological outcome was defined by a PCPC score of 1, 2 or 3 or no change from baseline PCPC which was determined based on historical data and chart review. Categorization at the time of discharge was determined by the discharge examination. Categorization at 1 and 3 mo after discharge was usually done by follow-up examination while at 6 mo was generally done by telephonic interview.

For patients with multiple arrest events, only the initial/index arrest event was described and analyzed. Primary outcome variable was immediate death or survival. Univariate and logistic regression analysis was performed using statistical software package, Stata 11.2 (College Station, Texas, USA). Factors that were significant on univariate analysis with $P < 0.05$ were entered in the logistic model.

3. Results

Fig. 1 shows the enrollments of patients and outcomes according to the Utstein template. Table 1 shows the descriptive data of events and outcomes. The largest age group was children more than 60-month-old. Of the patents, 264 (61.8%) were males and 278 (65.1%) were from rural region. Eighty-seven (20.4%) of children were severely undernourished. Site of CPR was the emergency room in 240 (56.2%), ward in 106 (24.9%) and pediatric intensive care unit in 81 (18.9%) children. Timing of CPR was at presentation in four (0.9%) patients, within 1 h of presentation in 48 (11.2%) and between 1 and 24 h in 206 (48.2%). The most common underlying illness was neurological in 110 (25.8%) of the patients. Respiratory compromise and arrest constituted about half of the total indications for CPR.

Two hundred and twenty two (51.9%) patients undergoing CPR could not be revived at all i.e. they died immediately. One hundred twelve (26.2%) patients attained sustained return of spontaneous circulation, but only 44 (10.3%) patients attained return of spontaneous ventilation and survived for more than 24 h. Only eight (1.9%) of patients were discharged from hospital after CPR and all of them survived for more than 6 mo.

Table 1
Descriptive data of 427 enrolled patients demographic and event features

Characteristics	n (%)
Age (in months) mean + SD	
1 mo to 12 mo	130 ± 30.4
12 mo to 60 mo	132 ± 31.0
>60 mo	165 ± 38.6
Male	264 (61.8)
Rural residence	278 (65.1)
Moderate under-nutrition	134 (31.4)
Severe under-nutrition	87 (20.4)
Location of cardiopulmonary resuscitation	
Emergency room	240 (56.2)
Ward	106 (24.9)
Pediatric intensive care unit	81 (18.9)
Duration of hospital stay before arrest	
On admission	4 (1.0)
<1 h	48 (11.2)
1–24 h	206 (48.2)
>24 h	169 (39.6)
Cardiopulmonary resuscitation during night hours	148 (34.7)
Underlying etiology	
Cardiovascular	40 (9.3)
Pulmonary	91 (21.3)
Neurological	110 (25.8)
Hepatic	40 (9.37)
Sepsis	74 (17.3)
Hematological	50 (11.7)
Renal	18 (4.2)
Metabolic	3 (0.7)
Endocrine	1 (0.2)
Associated co-morbidities	
Hyperkalemia	39 (9.1)
Hypokalemia	16 (3.7)
Metabolic acidosis	50 (11.7)
Tension pneumothorax	17 (4.0)
Cardiopulmonary resuscitation indications	
Respiratory compromise (agonal respiration)	98 (22.9)
Respiratory arrest	115 (27.0)
Bradycardia with poor perfusion	23 (5.4)
Cardiac arrest	191 (44.7)
Duration of cardiopulmonary resuscitation (in minutes) mean + SD	
≤10 min	135 ± 31.6
11–20 min	163 ± 38.1
>20 min	129 ± 30.2
≥2 adrenalin doses	356 (83.3)
Received calcium and sodium bicarbonate	402 (94.1)

Table 2 compares patient and event factors among those who died immediately and those who survived after initial CPR. It was found that age more than 12-month-old, CPR during night hours, cardiac arrest as indication of CPR, more than 10 min CPR duration, 2 or more doses of adrenalin and administration of intravenous calcium and sodium bicarbonate were associated with poor outcome. Table 3 compares patient

Table 2
Comparison of demographic features and events characteristics of patients associated with immediate death and immediate survival

Variables	Immediate death (n = 222) n (%)	Immediate survivors (n = 205) n (%)	Odds ratio for death (with 95% confidence interval)	P value
Age (>12 mo)	167 (75.2)	130 (63.4)	1.75 (1.13–2.72)	0.008
Female	86 (38.7)	77 (37.5)	1.05 (0.70, 1.58)	0.842
Urban residence	84 (37.8)	65 (31.7)	1.31 (0.86, 2.00)	0.188
Severe malnutrition	39 (17.5)	48 (23.4)	0.70 (0.42, 1.15)	0.149
Underlying etiology				
Cardiovascular	19 (8.6)	21 (10.2)	0.82 (0.42, 1.57)	0.550
Pulmonary	44 (19.9)	47 (23.3)	0.83 (0.52, 1.32)	0.433
Neurological	63 (28.3)	47 (23.3)	1.33 (0.86, 2.06)	0.198
Hepatic	22 (10.0)	18 (8.8)	1.14 (0.59, 2.19)	0.689
Sepsis	30 (13.5)	44 (21.4)	0.57 (0.34, 0.95)	0.030
Hematological	30 (13.5)	20 (10.0)	1.44 (0.79, 2.63)	0.227
Renal	10 (4.5)	8 (4.9)	1.16 (0.44, 3.00)	0.757
Metabolic	3 (1.4)	0 (0.0)	–	0.094
Endocrine	1 (0.5)	0 (0.0)	–	0.336
Night time cardiopulmonary resuscitation	105 (47.3)	43 (21.7)	3.38 (2.16, 5.32)	0.000
Cardiopulmonary resuscitation indications				
Respiratory compromise	37 (16.7)	61 (29.8)	0.47 (0.29, 0.75)	0.001
Respiratory arrest	52 (23.4)	63 (30.7)	0.68 (0.44, 1.05)	0.089
Bradycardia with poor perfusion	3 (1.4)	20 (9.8)	0.12 (0.03, 0.43)	0.000
Cardiac arrest	130 (58.6)	61 (29.8)	3.33 (2.83, 3.98)	0.000
>10 min cardiopulmonary resuscitation duration	211 (95.0)	81 (39.5)	29.36 (14.74, 62.99)	0.000
≥2 adrenalin doses	222 (100.0)	134 (65.3)	–	0.000
Received calcium and sodium bicarbonate	222 (100.0)	180 (87.8)	–	0.000

and event characteristics between those who died within 24 h and those who survived beyond 24 h after CPR. Again, CPR during night hours, clinical cardiac arrest as indication of CPR, more than 10 min CPR duration, age more than 12-month-old, 2 or more adrenalin doses and provision of intravenous calcium and sodium bicarbonate were significantly associated with poor outcome.

Table 4 shows the best fitting models for immediate death and death within 24 h after CPR. Of all the variables included night time CPR, more than 10 min CPR duration and cardiac arrest as indication of CPR were independently associated with poor immediate outcome, while night time CPR, age more than 1-year-old and cardiac arrest as indication of CPR were independently associated with death within 24 h after CPR. Out of eight patients, who were in PCPC category 1 before arrest, six were found in category 1 and one each in category 3 and category 4 at discharge and there was no change in 6-mo follow up. Good neurological outcome was found in seven (87.5%) patients at follow up.

4. Discussion

Herein, we describe the epidemiology of events leading to CPR in children and the outcome of pediatric CPR and identify the factors associated with poor outcome at a state run teaching hospital in northern India, based on Utstein template. An improved understanding of the epidemiology of in-hospital pediatric CPR is a necessary first step in our quest to identify risk factors for unsuccessful resuscitation and improve outcomes. Our study shows that overall outcome of in-hospital CPR is much inferior to studies from western nations [2,3,10–12]. Immediate survival or even 24 h survival does not translate into ultimate survival. However, those surviving until discharge usually go on to have intact ultimate survival. The glaring difference in the outcome in our study when compared to the previous studies can be attributed to the following factors: (a) Children living in rural areas report very late to the hospital. (b) Under-nutrition was found in most of the children in our study. (c) The worst outcome was found in patients with underlying neurological and

Table 3
Comparison of demographic features and events characteristics of patients associated with 24-h survival and death within 24-h

Variables	24 h survival (n = 61) n (%)	Death within 24 h (n = 366) n (%)	Odds ratio for death (with 95% confidence interval)	P value
Age (>12 mo)	27 (44.2)	270 (73.7)	2.54 (1.95, 6.43)	0.000
Female	21 (34.4)	142 (38.7)	1.21 (0.66, 2.25)	0.570
Urban residence	19 (31.1)	130 (35.5)	1.22 (0.66, 2.31)	0.563
Severe under nutrition	11 (18.0)	76 (20.7)	1.19 (0.58, 2.66)	0.732
Underlying etiology				
Cardiovascular	8 (13.1)	32 (8.7)	0.63 (0.27, 1.45)	0.278
Pulmonary	17 (27.9)	74 (20.2)	0.65 (0.35, 1.21)	0.176
Neurological	11 (18.0)	99 (27.0)	1.68 (0.84, 3.36)	0.136
Hepatic	5 (8.2)	35 (9.6)	1.18 (0.44, 3.15)	0.734
Sepsis	14 (23.5)	60 (16.4)	0.65 (0.34, 1.27)	0.210
Hematological	4 (6.6)	46 (12.6)	2.04 (0.70, 5.91)	0.176
Renal	2 (3.2)	16 (4.4)	1.34 (0.30, 6.01)	0.694
Metabolic	0 (0.0)	3 (0.8)	–	0.503
Endocrine	0 (0.0)	1 (0.3)	–	0.479
Night time cardiopulmonary resuscitation	9 (14.7)	139 (37.9)	3.54 (1.66, 8.41)	0.000
Cardiopulmonary resuscitation indications				
Respiratory compromise	26 (42.6)	72 (20.6)	0.33 (0.18, 0.58)	0.000
Respiratory arrest	18 (30.4)	97 (26.5)	0.86 (0.47, 1.56)	0.624
Bradycardia with poor perfusion	5 (8.1)	18 (5.0)	0.58 (0.20, 1.62)	0.219
Cardiac arrest	12 (20.3)	179 (49.0)	3.90 (2.01, 7.59)	0.000
>10 min cardiopulmonary resuscitation duration	0	292 (79.7)	–	0.000
≥2 adrenalin doses	0	356 (97.2)	–	0.000
Received calcium and sodium bicarbonate	38 (62.2)	364 (99.4)	110.16 (25.09, 977.44)	0.000

Table 4
Factors independently associated with outcome

Factors	Immediate death		Death within 24 h	
	Adjusted odds ratio (95% confidence interval)	P value	Adjusted odds ratio (95% confidence interval)	P value
Cardiopulmonary resuscitation during night hours	3.7360 (2.09, 6.65)	0.000	3.17 (1.14, 6.97)	0.004
>10 min duration of cardiopulmonary resuscitation	27.04 (13.18, 55.50)	0.000	–	
Cardiac arrest as indication of cardiopulmonary resuscitation	2.56 (1.32, 4.95)	0.005	4.93 (2.24, 10.85)	0.000
Age (>12 mo)			5.52 (2.76, 11.04)	0.000

hematologic-oncological illness and they together constituted high proportion of patients in our study. In this context, it is also noteworthy that the concept of “do not resuscitate” consent is not prevalent in our country. (d) Lack of proper monitoring facilities including electrocardiographic rhythm before arrest and overburdened doctors and paramedical staff in our hospital typical of a developing country contributed to poor outcome. Thus,

establishment of an adequate response mechanism in future might increase the chances of survival. (e) There is also no formal pediatric basic and advanced life support training in our institution, which adversely affected the quality of CPR in our study.

We found that infants constituted a high proportion of patients who attained ROSC and ROSV with better immediate and 24 h survival. One of the reasons for

this may be that most of the arrests in younger age group are asphyxial in origins, which respond to early institution of respiratory support. Similar results were also found in previous studies [10,11,13]. There was no significant difference in outcome based on location of CPR. Several multicenter, as well as tertiary care hospital studies have also reported no difference in outcome based on location of CPR [3,10–12,14].

The underlying etiology of the arrest can be an important determinant of outcome. Among the patients who achieved sustained ROSC and ROSV, the most common underlying illness was found to be respiratory. Patients with underlying neurological and hematologic-oncological illness had the worst outcome, with only 10% 24 h survivors in each category. Another Asian study showed poor outcome among patients with underlying hematologic-oncological illness [10], while still other Asian and western studies showed the survival was least among the patients who had sepsis as their underlying illness [2,11]. The unique finding of high mortality in patients with underlying neurological illness is because the majority were suffering from acute viral encephalitis which itself has a bad outcome.

In the present study we noted that CPR required during night hours resulted in significantly inferior chances of reaching sustained ROSC 23/148 (6.4%) and ROSV 7/148 (4.7%). In our hospital during night hours, the shifts in wards are shared by unfixed residents. Therefore, the duty residents might be unfamiliar with patients' condition and may be less available to individual patients because of increased volume of cross coverage. The cumulative effect of low manpower during the night hours in the hospital could lead to poor CPR quality. Developing an adequate response mechanism, such as medical emergency teams is helpful to enable early detection of potentially correctable events and to provide high CPR quality. There are two earlier studies reporting similarly poor outcome during night hours [10–13].

We also found that longer CPR duration were associated with poor outcome. Of the patients who were resuscitated for more than 10 min, only 15 (5.1%) attained sustained ROSC and only one achieved ROSV. None of the patients who received more than 10 min CPR survived for more than 24 h ($P = 0.000$). Similar findings are also reported in earlier literature [11,15]. Of course, this may only mean that the patient was not being revived and therefore resuscitation efforts were continued for longer time.

Requirement for additional number of doses of adrenaline and of calcium and sodium bicarbonate

injections was associated with inferior outcomes. None of the patients who received 2 or more doses of adrenaline survived for more than 24 h ($P = 0.000$). In a similar study, the relative risk of mortality in hospital of the group who needed adrenaline was 3.76 (95% confidence interval [CI]: 1.83–7.73) [2]. There are other studies also favoring the poor outcome with increase in number of doses of adrenaline [3,11]. Similarly, all the patients who died immediately had received calcium and sodium bicarbonate. The odds ratio (OR) for death within 24 h for these patients was very high (110.16) compared to those who did not receive these drugs. This finding is similar to previous studies [10,16]. Again repeated doses of adrenaline and giving calcium and bicarbonate may simply mean that the patient was not being revived and so-called last-ditch efforts were made in an attempt to resuscitate the patient.

Controlling for confounding variables, multiple logistic regression analysis revealed independent association of immediate death with CPR during night hours, more than 10 min duration of CPR, and cardiac arrest as indication of CPR. Similarly, the independent factors associated with death within 24 h were night-time CPR, age more than 1-year-old, and cardiac arrest as indication of CPR. Reis et al. [3] found an independent association between 24-h survival and respiratory failure as the precipitating cause of the arrest (OR:4.92; 95%, CI:1.73–14.0), bradycardia with poor pulses as the initial event (OR:2.68; 95%, CI:1.01–7.1), and duration of the resuscitation (OR:0.92; 95%, CI:0.89–0.96 for each elapsed min). Wu et al. [10] in a multivariate analysis showed that patients who had vasoactive drug infusions before CPR, hematologic or oncologic diseases, and longer CPR durations had decreased chances of survival to hospital discharge.

The ultimate goal of CPR, like any other life-saving effort, is neurologically intact survival. In the present study, the final neurologic status was the same as the prearrest status in 6/8 (75%) of those discharged from the hospital and remained unchanged at 6 mo follow up. Overall good neurological outcome was found in 7/8 (87.5%) of patients at 6 mo follow up. Previous studies have also reported that majority of survivors had neurologic status that was either normal or unchanged from baseline status [3,17–19]. More subtle neurologic changes, such as learning disabilities, cannot be assessed with the PCPC scales. Morris and Nadkarni [20] demonstrated that there were subtle neurologic deficits in survivors of cardiac arrest; however, they did not determine the presence or absence of neurologic deficits in the pre-arrest state.

The strengths of our study are that the relatively large number of patients ($n = 427$) were enrolled. Limitations include the relatively small number of patients in some sections of the template due to which calculation of all possible rates or percentages may fail to adequately express the potential clinical variability that exists. Analysis of only the index event among the patients who experienced more than one arrest event also contributes to the weakness of the study as the outcome might have been affected by subsequent events. Accurate classification of the cause of arrest or need for advanced life support was not always possible because of difficulty in clearly identifying the proximate disease process causing the event. For example, should a child with viral encephalitis who suffers aspiration leading to respiratory failure be classified as a primary central nervous system etiology, or respiratory etiology? Our study also did not record the electrocardiography to assess the rhythm before arrest.

In conclusion, this pioneering study from India shows that cardiopulmonary resuscitation in our setting has an overall poor outcome compared to studies from Western centers. Training of resident doctors and paramedics in resuscitation may be a reasonable first step by the hospitals to improve outcome. Results of our study can be extrapolated to other government teaching hospital in India.

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