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Clinical paper

Post-resuscitative clinical features in the first hour after achieving sustained ROSC predict the duration of survival in children with non-traumatic out-of-hospital cardiac arrest☆

Yan-Ren Lin[a,c,*], Chao-Jui Li[b], Tung-Kung Wu[c], Yu-Jun Chang[d,f], Shih-Chang Lai[a,c], Tzu-An Liu[g], Ming-Hau Hsiao[a], Chu-Chung Chou[a,e], Chin-Fu Chang[a]

[a] Department of Emergency Medicine, Changhua Christian Hospital, Changhua, Taiwan
[b] Department of Emergency Medicine, Chang Gung Memorial Hospital, Kaohsiung Medical Center, Chang Gung University College of Medicine, Kaohsiung, Taiwan
[c] Department of Biological Science and Technology and Institute of Biochemical Engineering, National Chiao Tung University, Hsinchu, Taiwan
[d] Epidemiology and Biostatistics Center, Changhua Christian Hospital, Changhua, Taiwan
[e] Institute of Medicine, Chungshan Medical University, Taichung, Taiwan
[f] Institute of Environmental Medicine, China Medical University, Taichung, Taiwan
[g] Institute of Cellular and System Medicine, National Health Research Institutes, Zhunan, Miaoli County, Taiwan

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ABSTRACT

Aim of the study: Although sustained return of spontaneous circulation (ROSC) can be initially established after resuscitation from non-traumatic out-of-hospital cardiac arrest (OHCA) in some children, many of the children lose spontaneous circulation during hospital stay and do not survive to discharge. The aim of this study was to determine the clinical features during the first hour after ROSC that may predict survival to hospital discharge.
Methods: We retrospectively evaluated the medical records of 228 children who presented to the emergency department without spontaneous circulation following non-traumatic OHCA during the period January 1996 to December 2008. Among these children, 80 achieved sustained ROSC for at least 20 min. The post-resuscitative clinical features during the first hour after achieving sustained ROSC that correlated with survival, median duration of survival, and death were analyzed.
Results: Among the 80 children who achieved sustained ROSC for at least 20 min, 28 survived to hospital discharge and 6 had good neurologic outcomes (PCPC scale = 1 or 2). Post-resuscitative clinical features associated with survival included sinus cardiac rhythm ($p = 0.012$), normal heart rate ($p = 0.008$), normal blood pressure ($p < 0.001$), urine output > 1 ml/kg/h ($p = 0.002$), normal skin color ($p = 0.016$), lack of cardiopulmonary resuscitation (CPR)-induced rib fracture ($p = 0.044$), initial Glasgow Coma Scale score > 7 ($p < 0.001$), and duration of in-hospital CPR ≤ 10 min ($p < 0.001$). Furthermore, these variables were also significantly associated with the duration of survival (all $p < 0.05$).
Conclusions: The most important predictors of survival to hospital discharge in children with OHCA who achieve sustained ROSC are a normal heart rate, normal blood pressure, and an initial urine output > 1 ml/kg/h.

1. Introduction

Pediatric out-of-hospital cardiac arrest (OHCA) is rare and the rate of survival is very low.[1–6] Although sustained return of spontaneous circulation (ROSC) can be initially established after resuscitation from non-traumatic OHCA in up to 35% of children, the rate of survival to hospital discharge is only 6–12%, and only 2–4% of those children have good neurologic outcome.[1,2] Some studies have shown that survival of children with OHCA is associated with factors in the pre-hospital resuscitation period, such as whether the arrest was witnessed, initial cardiac rhythm, and bystander resuscitation.[7–9] The post-resuscitative clinical features that may be predictive of survival and duration of survival in children, however, have not been well addressed.

The aim of this study was to determine the clinical features during the first hour after ROSC that may predict survival in children with non-traumatic OHCA.

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* Corresponding author at: Department of Emergency Medicine, Changhua Christian Hospital, 135 Nanshsiao Street, Changhua 500, Taiwan.
Tel.: +886 4 7238595x1374; fax: +886 4 7289233.
E-mail address: h6213.lac@gmail.com (Y.-R. Lin).

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2. Methods

2.1. Study design

Children aged ≤ 18 years who presented to the emergency department (ED) of either the Chang Gung Memorial Hospital or the Changhua Christian Hospital with OHCA of non-traumatic origin during the period January 1996–December 2008 were included in this study. Patient characteristics and post-resuscitative clinical features that may be associated with the outcomes of children with OHCA were analyzed retrospectively. The study protocol was approved by the Institutional Review Boards of both hospitals.

2.2. Study setting and population

We retrospectively reviewed the medical records of 238 children aged ≤ 18 years with non-traumatic OHCA who presented to the ED at the Chang Gung Memorial Hospital (CGMH) in southern Taiwan or the Changhua Christian Hospital (CCH) in central Taiwan. The CGMH is a 2500-bed medical center covering a population of 1,700,000 individuals, among whom 330,000 are children. The incidence of pediatric OHCA at that institution is 4.7/100,000. The CCH is a 2000-bed medical center covering a population of 1,500,000 individuals, among whom 330,000 are children. The incidence of pediatric OHCA at that institution is 4.5/100,000. Among the 238 children, 10 were brought to the CGMH ($n = 4$) or the CCH ($n = 6$) without resuscitation attempts because of "do not resuscitate" orders and were declared dead on arrival. Data on these children were excluded from the analysis. Therefore, the study population comprised 228 children. All of the OHCA children were obtained from the database for tracking arrest without missing cases. None of the patients had spontaneous circulation upon arrival at the ED. The organization of local public emergency medical systems and the training of EMS personnel are similar in both southern and central Taiwan. Pre-hospital basic life support (BLS) provided by EMS personnel included chest compression, use of automated external defibrillator, and use of non-invasive ventilation, such as a Bag-Valve-Mask. The decision to stop resuscitation was made only by ED physicians after a detailed clinical assessment indicated that achieving successful resuscitation was not possible.

Patients in this study were divided into 8 major groups based on the possible etiology of the OHCA: (1) sudden infant death syndrome; (2) infections (including upper and lower respiratory tract infection, urinary tract infection, deep neck infection, and infective colitis); (3) cardiovascular diseases (including myocarditis, heart failure, and congenital heart diseases); (4) neurological disease (including status epilepticus, spontaneous intracranial hemorrhage, and hydrocephalus); (5) asphyxia (caused by acute or chronic respiratory failure, food bolus or foreign body airway obstruction); (6) malignancy; (7) intoxication (drug or substance overdose); and (8) idiopathic causes. Classification of etiology was based on a detailed history, clinical assessment, laboratory investi-

Table 1
Patient characteristics and factors associated with sustained ROSC in non-traumatic OHCA children.

	Non-traumatic OHCA children ($n = 228$) No. (%)	Sustained ROSC		
		Yes ($n = 80$)	No ($n = 148$)	p-value
Age (mean ± SD) (y/o)	4.82 ± 5.42			
Newborn	29 (12.7)	14	15	0.622
Infant	85 (37.3)	25	60	
Toddler	36 (15.9)	16	20	
Preschool	20 (8.7)	8	12	
School	23 (10.3)	9	14	
Adolescence	35 (15.1)	8	27	
Sex				
Boy	123 (54)	47	76	0.289
Girl	105 (46)	33	72	
Place of cardiac arrest[a]				
Home	185 (81)	55	130	0.011
Outside the home	43 (19)	25	18	
Witnessed arrest[a]				
Yes	148 (64.9)	66	82	0.002
No	80 (35.1)	14	66	
The period from scene to hospital[a] (min)	28.12 ± 19.54 (11)[b]	20.67 ± 13.23	34.28 ± 20.57	<0.001
Pre-hospital BLS duration[a] (mean ± SD) (min)	14.10 ± 12.67 (9)[b]	10.22 ± 5.82	19.98 ± 16.61	0.005
Etiology				
Sudden infant death syndrome	43 (19)	10	33	0.583
Infections	31 (13.5)	13	18	
Cardiovascular diseases	23 (10.3)	10	13	
Neurological diseases	29 (12.7)	14	15	
Asphyxia	60 (26.2)	20	40	
Malignancy	23 (10.3)	8	15	
Intoxication	5 (2.4)	1	4	
Idiopathic	14 (5.6)	4	10	
Initial cardiac rhythm[a]				
Asystole	152 (66.7)	38	114	<0.001
PEA	42 (18.3)	18	24	
VF[c]	34 (15.1)	24	10	
Body weight (mean ± SD) (kg)	17.51 ± 13.16 (12)[b]	16.24 ± 14.76	17.22 ± 15.69	0.824
In-hospital CPR duration[a] (mean ± SD) (min)	33.36 ± 17.12	13.39 ± 8.56	38.57 ± 21.88	<0.001

[a] Factors associated with achieving sustained ROSC in the ED.
[b] Number of patients with missing information.
[c] VF includes patients with pulseless VT.

gations, and radiological examinations. Etiologies that were unclear were classified as idiopathic causes. In addition, children were also divided into 6 groups according to age: newborn (<1 month), infant (1–12 months), toddler (>12 months to 3 years), preschool (>3–5 years), school age (>5–12 years), and adolescent (>12–18 years).

2.3. Study protocol

Information relating to the pre-hospital phase of resuscitation and BLS, including location of cardiac arrest and the duration of pre-hospital CPR, was obtained from public EMS records and witness statements. Children with OHCA received in-hospital resuscitation according to the advanced pediatric life support (APLS) protocol in both centers. The protocols adhered to the pediatric Utstein reporting system.[6] In this study, in-hospital CPR was defined as resuscitation attempts performed in the ED. All treatments and decisions regarding the termination of resuscitation efforts were made at the discretion of the treating physician. Data on patient characteristics gathered from ED patient charts included initial vital signs, age, sex, initial cardiac rhythm on presentation to the ED, duration of in-hospital CPR, body weight, body temperature (measured by an infrared ear thermometer), medications administered during CPR, the duration of in-hospital CPR, and clinical features during the post-resuscitation phase. In this study, the initial cardiac rhythm on presentation to the ED was obtained from electrocardiographic monitor that had been recorded immediately upon arrival. The rhythms included ventricular fibrillation (VF), pulseless ventricular tachycardia, pulseless electrical activity (PEA), and asystole. In this study, VF includes patients with pulseless ventricular tachycardia. Sustained ROSC was defined as that which resulted in at least 20 min of ROSC.[10]

The duration of survival was defined as the period from the time the patient achieved sustained ROSC in the ED to death or discharge from hospital. The following post-resuscitative clinical features evaluated in this study had been monitored and recorded by ED physicians or nurses every 10–15 min during the first hour after children had achieved spontaneous circulation: (1) cardiac rhythm (sinus, ventricular, and junctional rhythms) and heart rate (normal, tachycardia, bradycardia). Ventricular rhythm included ventricular pre-mature contractions and idioventricular rhythm. These data were obtained from electrocardiograms. The dominant cardiac rhythm and heart rate during the post-resuscitative period in each child were chosen for analysis; (2) mean arterial blood pressure (MAP). In this study, normal blood pressure was defined in children with MAP values within the normal range for children of the same age; hypertension was defined in children with MAP values that were higher than the normal range for children of the same age; and hypotension was defined as MAP values

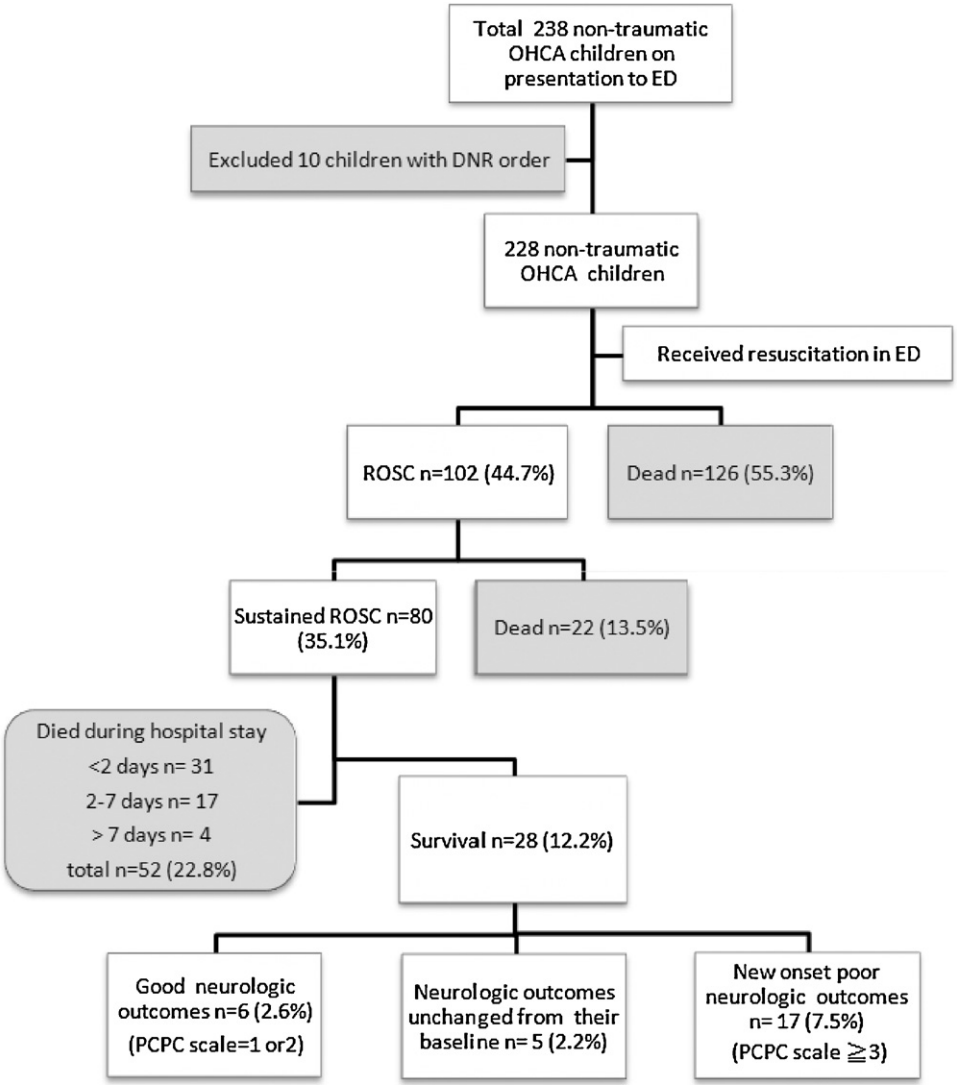

Fig. 1. The outcomes of all non-traumatic OHCA children.

that were lower than the normal range for children of the same age. In patients with large variations in blood pressure readings, the dominant blood pressure was used for analysis; (3) skin color of the face and trunk (normal, pale, cyanotic); (4) urine output (>1, 1–0.5, <0.5 ml/kg/h) and color of urine (straw-yellow, dark, blood-tinged). These data were recorded from the urine drained from urinary catheters that had been inserted immediately after patients had achieved sustained ROSC. Urine drained from urinary catheters during catheterization was regarded as residual urine and was not considered post-resuscitative urine output. The color of the urine was determined after the initial urine had been discarded; (4) presence of rib fracture. The diagnosis of fracture was made by ED physicians or radiologists based on radiographic evidence on portable chest X-ray images that had been obtained in all children immediately after they had achieved sustained ROSC. Old rib fractures and those associated with possible child abuse were not included in this study; (5) the initial Glasgow Coma Scale (GCS) (>7, 7–4, 3). All verbal scores were graded as 1 because all patients had an artificial airway. The highest score during the first 1-h interval after achieving sustained ROSC was chosen for analysis; and (6) body temperature. Moreover, the mean blood pressures and heart rates were reported respectively in 4 time periods during their ED stay (≤15, 16–30, 31–45, 46–60 min) for analyzing the cardiac output in children who survived to discharge and in children who did not survive to discharge. The mean value would be chosen when children who had more than one measured data in one time period.

The total amount of fluid (including crystalloid fluid, colloid fluid, and blood products) administered during in-hospital CPR (from the time patients arrived at the ED until they achieved sustained ROSC) was recorded and categorized as >61, 60–41, 40–21 and ≤20 ml/kg.

Neurologic outcomes of children who survived to discharge were evaluated according to the Pediatric Cerebral Performance Category (PCPC) scale before cardiac arrest (baseline), at the time of discharge from the hospital, and at follow-up. The PCPC scale range from 1 (no disability) to 5 (coma or vegetative state). In this study, survivors were divided into 3 groups based on neurologic outcome: (1) good neurologic outcome (PCPC scale = 1 or 2); (2) neurologic outcome unchanged from baseline (no deterioration in PCPC scale categories); and (3) poor neurologic outcome (PCPC scale ≥ 3).

2.4. Data analysis

Descriptive analyses of independent variables (age, sex, etiologies of OHCA, pre-hospital information, duration of in-hospital CPR, medication dosage, post-resuscitative clinical features, and duration of survival) are reported as percentages or mean ± standard deviation (SD). Factors that may be associated with sustained ROSC and survival were analyzed by the by Mann–Whitney *U*

Table 2
Association between post-resuscitative clinical features during the first hour after achieving sustained ROSC and survival.

	Children who achieved sustained ROSC (n = 80)		
	Survived to discharge		p-value
	Success (n = 28)	Failure (n = 52)	
Type of cardiac rhythm[a]			
Sinus rhythm	22	23	0.012
Ventricular rhythm	4	21	
Junction rhythm	2	8	
Hear rate[a]			
Normal heart rate	13	10	0.008
Tachycardia	13	25	
Bradycardia	2	17	
Blood pressure[a]			
Normal blood pressure	11	8	≤0.001
Hypertension	13	11	
Hypotension	4	33	
Urine output[a]			
>1 ml/kg/h	13	8	0.002
1–0.5 ml/kg/h	12	21	
<0.5 ml/kg/h	3	23	
CPR-induced rib fracture[a]			
Yes	2	13	0.044
No	26	39	
Color of urine			
Straw-yellow	11	27	0.531
Dark	11	15	
Blood-tinged	6	10	
Color of skin[a]			
Normal	13	13	0.016
Pale	12	18	
Cyanotic	3	21	
Initial GCS[a]			
>7	13	2	<0.001
7–4	9	30	
3	6	20	
Number of epinephrine injections (mean ± SD)	4.92 ± 3.76	9.46 ± 5.83	0.582
Epinephrine total dose (mean ± SD) (mg/kg)	0.32 ± 0.25	0.42 ± 0.41	0.884
Body temperature (mean ± SD) (°C)	35.87 ± 2.15	34.77 ± 1.78	0.952
Duration of in-hospital CPR[a] (mean ± SD) (min)	9.57 ± 13.63	14.37 ± 12.76	<0.001

[a] Factors associated with survival.

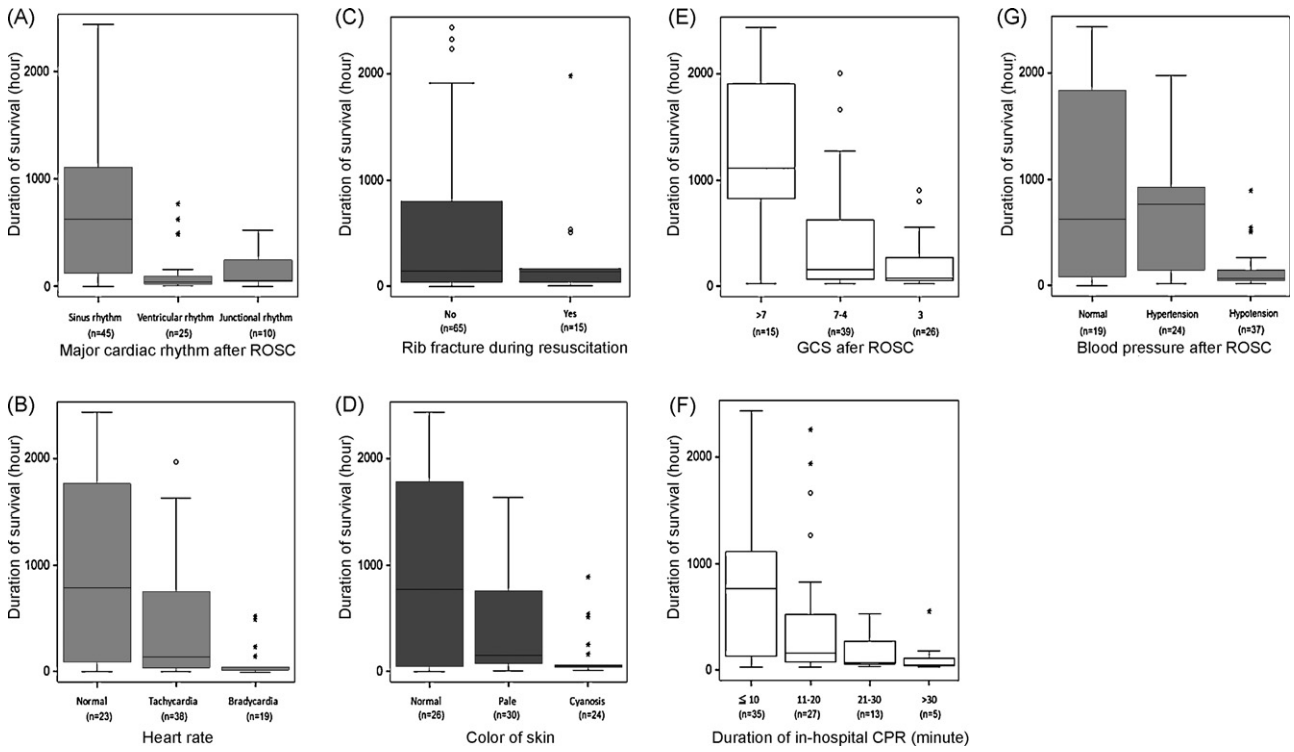

Fig. 2. Post-resuscitative clinical features in the first hour after achieving sustained ROSC associated the durations of survival in non-traumatic OHCA children. (A) The major type of cardiac rhythm; (B) heart rate; (C) rib fracture caused by CPR; (D) the color of skin; (E) initial GCS; (F) the duration of in-hospital CPR; (G) the blood pressure (analyzed by non-parametric test and all $p < 0.05$).

test, Fisher's exact test, or Chi-Square test. Relationships between post-resuscitative clinical features of patients and duration of survival were analyzed by a non-parametric test (Mann–Whitney *U* test or Kruskal–Wallis test) and the results are reported as a box plot. Multiple logistic regression analysis was used to analyze the relationship between survival and rib fracture after adjusting for duration of CPR. A p-value < 0.05 was considered to be statistically significant. All analyses were performed using SPSS software version 15.0 (SPSS Inc., Chicago, IL).

3. Results

3.1. Patient characteristics and factors related to sustained ROSC

Data on 228 children with OHCA of non-traumatic origin were analyzed. Patient characteristics are presented in Table 1. Among the 228 patients, sustained ROSC was achieved in 80 children. The overall mortality rate was 87.8%. A total of 28 patients survived to discharge. Among them, 6 had good neurologic outcomes and 17 had poor neurologic outcomes (Fig. 1). The factors that were positively associated with achieving sustained ROSC in the ED are also shown in Table 1.

3.2. Clinical features during the first hour after achieving sustained ROSC

Among the 80 children who achieved sustained ROSC, only one died in the ED within the first hour. The mean duration of ED stay was 1.62 ± 0.43 h. During the first hour after achieving sustained ROSC, the major type of cardiac rhythm was sinus rhythm (56.3%) followed by ventricular rhythm (31.3%) and junctional rhythm (12.4%). The most common heart rate was tachycardia (47.5%) followed by normal heart rate (28.8%) and bradycardia (23.7%). The most common blood pressure status was hypotension (46.3%). Most of the children (41.3%) had a urine output of 0.5–1 ml/kg/h, and the most common color of urine was straw-yellow. Fifteen (18.8%) children had CPR-induced rib fracture. Thirty (37.5%) children had pale skin color and 24 (30%) were cyanotic after achieving sustained ROSC. Most children had an initial GCS score in the range of 4–7 (Table 2). The mean number of epinephrine injections was 6.73 ± 4.54 and the mean total dose of epinephrine was 0.39 ± 0.27 (mg/kg).

3.3. Likelihood of survival according to clinical features during the first hour after achieving sustained ROSC

Clinical features during the first hour after achieving sustained ROSC that were significantly predictive of survival included cardiac rhythm, heart rate, blood pressure status, urine output, CPR-induced rib fracture, skin color, initial GCS score, and duration of in-hospital CPR (Table 2).

3.4. Associations between clinical features in the first hour after achieving sustained ROSC and the median duration of survival

The duration of survival of the 80 children who achieved sustained ROSC in the ED ranged from 0.4 to 2456 h. The median duration of survival was significantly longer in patients with sinus rhythm than in patients with ventricular or junctional rhythm (Fig. 2A) and significantly shorter in patients with bradycardia after sustained ROSC than patients with normal heart rate or tachycardia (Fig. 2B). Children with CPR-induced rib fracture had a shorter median duration of survival than children without rib fracture (Fig. 2C). The mean duration of pre-hospital CPR and total duration of CPR (pre-hospital plus in-hospital) were longer in patients with rib fracture (13.47 ± 6.62

and 31.34 ± 18.42 min) than in patients without rib fracture (10.58 ± 11.73 and 26.42 ± 15.54 min). After adjusting for total duration of CPR, multiple logistic regression analysis revealed that CPR-induced rib fracture was a significant predictor of poor survival (OR: 6.21, 95% CI: 1.17–32.83, $p = 0.032$). Children with cyanotic skin color during the post-resuscitative period had a significantly shorter median duration of survival than children with pale or normal skin color (Fig. 2D). In addition, children with an initial GCS > 7 had a longer median duration of survival than children with GCS ≤ 7 (Fig. 2E).

Among the 80 children who achieved sustained ROSC in the ED, 43.8% ($n = 35$) achieved a return of spontaneous circulation after less than 10 min of in-hospital CPR. Our analysis revealed an inverse correlation between median duration of survival and length of in-hospital CPR (Fig. 2F). In addition, children with post-resuscitative hypotension had a shorter median duration of survival than children with normal blood pressure or hypertension (Fig. 2G). We also found that children with an initial urine output > 1 ml/kg/h had a longer median duration of survival than children with urine output < 1 ml/kg/h. There was a direct association between the duration of survival and urine output (Fig. 3A) (all $p < 0.05$). The MAP and heart rate during the first hour after achieving sustained ROSC were significantly higher in children who survived to discharge than in children who did not survived to discharge (Fig. 4A and B).

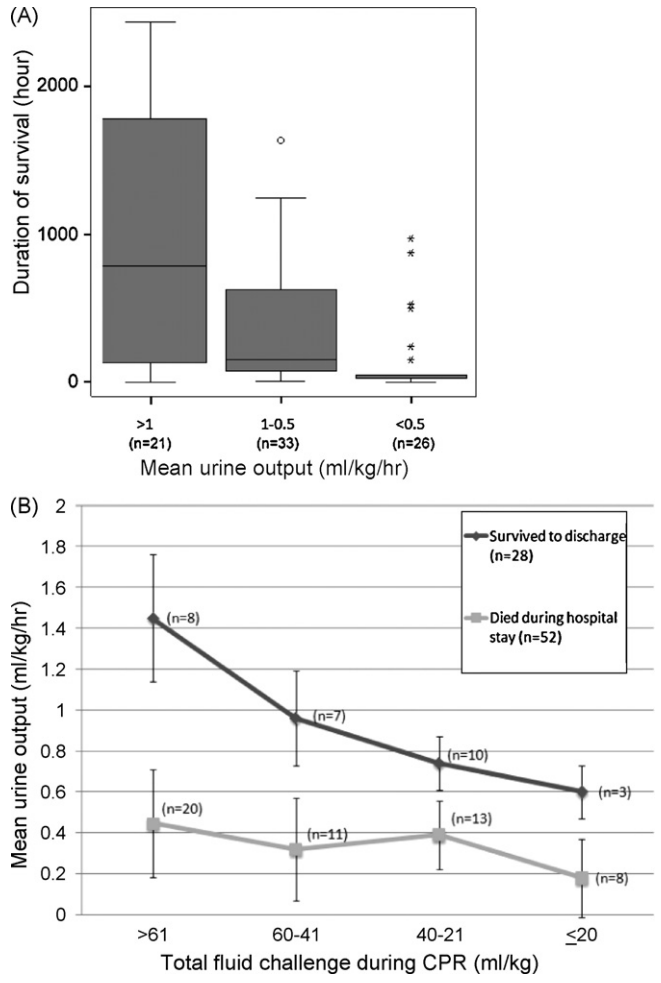

Fig. 3. The urine output in the first hour after achieving sustained ROSC (A) associated the different durations of survival ($p < 0.001$) and (B) the initial urine output increased in proportion to the amount of fluid administered during CPR in patients who survived to discharge.

3.5. The relationship between volume of fluid administered during CPR and urine output in children with sustained ROSC

We found that in patients who survived to discharge ($n = 28$), the initial urine output increased in proportion to the amount of fluid administered during CPR. However, in children who died during hospital stay ($n = 52$), the initial urine output was very low and the mean urine output was not >0.5 ml/kg/h, even in patients who had received massive fluid challenge during CPR (Fig. 3B).

3.6. Good neurologic outcomes of survivors

All survivors with good neurologic outcomes had sinus rhythm and normal heart rate or tachycardia when spontaneous circulation returned. None of them had an initial urine output lower than 0.5 ml/kg/h and none of them had CPR-related chest injuries. In addition, the total duration of CPR (pre-hospital plus in-hospital) was <25 min and the duration of in-hospital CPR was <15 min. With the exception of one child, all children showed deterioration in at least one PCPC scale category.

4. Discussion

Although sustained ROSC can be initially established after resuscitation from non-traumatic OHCA in some children, many of the children lose spontaneous circulation during hospital stay and do not survive to discharge.[2] It remains challenging for ED physicians to predict the survival after OHCA in children, especially in children with unstable signs in the post-resuscitative period. In this study, we have analyzed the post-resuscitative clinical features that may predict the chances of survival and the duration of survival.

Previous studies have shown that the initial cardiac rhythm (immediately upon arrival or at the scene) plays an important role in predicting the survival of OHCA children.[3,7] In this study, we found that sinus rhythm in the post-resuscitative period was associated with survival. Furthermore, we found that children with initial ventricular and junctional rhythm had a shorter duration of survival than children with sinus rhythm. In addition, normal heart rate and tachycardia were both associated with survival. Very few children who presented with bradycardia during the post-resuscitative period survived to discharge and none of them had good neurologic outcomes. Therefore, close monitoring of cardiac rhythm and rate during the post-resuscitation period and providing appropriate management are important after children achieve sustained ROSC.

Although CPR-induced rib fracture is common and has been shown to be associated with poor outcome in adult OHCA patients. Lederer et al. analyzed the autopsy and chest X-ray reports of adult OHCA patients and found that CPR-induced rib fracture occurred in up to 94.7% of cases,[11] the relationship between rib fracture caused by CPR and outcome of children with OHCA who achieve sustained ROSC have not been well analyzed. In this study, we found that rib fracture was associated with prolonged CPR duration and children with rib fracture had lower chance to survive than children without CPR-induced fracture after adjusting for total duration of CPR. A few studies have reported that CPR-induced rib fracture is not common in pediatric patients.[12] For example, in a series of 923 children who received CPR, rib fracture occurred in only 3 patients.[13] In our study, however, 15 of the 80 children suffered CPR-induced rib fracture. One of the possible reasons for the higher incidence of rib fracture in our study is resuscitation improperly performed by bystanders. According to the EMS records, 9 children with rib fracture had received a precordial thump by a witness to the cardiac arrest before the EMS had arrived.

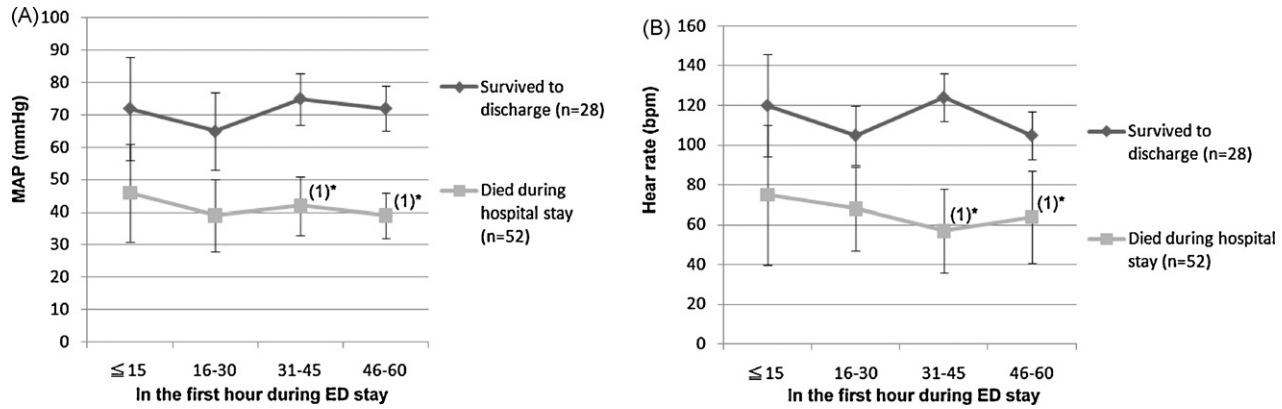

Fig. 4. The MAP (A) and heart rate (B) which might associate with post-resuscitative cardiac output were all higher in children who survived to discharge than in children who did not survive to discharge in the 4 time points during the first hour of their ED stay. *Number of patients with missing information.

Oxygenation can be assessed by measuring PaO_2 levels and by pulse oximetry; however, skin color assessment is a simpler, more rapid method for assessing oxygen delivery, especially in the ED (PaO_2 need withdraw the blood and pulse oximetry might be affected by incorrect sensor application and movements). Cyanotic skin color during the post-resuscitation period in the ED can be interpreted as a sign of severe hypoxia. In this study, we found that cyanotic skin color was associated with poor survival and shorter duration of survival. In fact, none of the children who survived to discharge with good neurologic outcomes had cyanotic skin color during the post-resuscitation period.

Prolonged CPR has an impact on the ultimate prognosis of children with non-traumatic OHCA.[2,14] In this study, we found that the duration of in-hospital CPR is a significant predictor of survival. Among the children who initially achieved a sustained ROSC in the ED, those who received in-hospital CPR for more than 20 min had a markedly shorter duration of survival and none of them survived to discharge with good neurologic outcomes.

Studies have shown that urine output is associated with the severity of hypovolemia.[15–17] However, the association between the amount of urine output and the prognosis of children with non-traumatic OHCA has not been well addressed. In this study, we found that initial urine output in the first hour after achieving sustained ROSC is associated with the duration of survival. Urine output > 1 ml/kg/h was associated with longer duration of survival. In children who survived to discharge ($n = 28$), their first hour urine output increased in proportion to the total amount of fluid that had been administered during CPR. In children who died during hospital stay ($n = 52$), their first hour urine output was not dependent on the amount of fluid that had been administered. The urine output in the first hour after achieving sustained ROSC might reflect the initial post-resuscitative hemodynamic status (including relative hypovolemia and the perfusion status of the urinary system). Adequate urine output in the initial post-resuscitation phase can indicate stabilization of hemodynamic status, and, therefore, better outcome. In fact, the initial urine output was not lower than 0.5 ml/h/kg in any of the children who survived to discharge with good neurologic outcomes. Therefore, patients might be more stable when a balance between fluid input and urine output is reached after achieving sustained ROSC.

Previous studies have demonstrated that the outcomes of OHCA patients could be better if cardiac function returned as soon as possible.[18–20] We thought that the post-resuscitative blood pressure and heart rate directly associated with the initial cardiac output. Moreover, the end organ perfusion (i.e., urinary system perfusion) which was also associated with cardiac output could be reflected by urine output. Therefore, the initial blood pressure, heart rate and urine output were important clinical features for primary clinicians to predict the outcomes of OHCA children and monitoring the blood pressure and heart rate should be emphasized.

4.1. Limitations

To our knowledge, children who experience an OHCA but who do not present with neurologic deficits are prime candidates for cardiac resuscitation. In this study, however, only 6 children were discharged with good neurologic outcomes. Therefore, factors associated with good neurologic outcomes were difficult to analyze. In addition, data from 11 patients were excluded from the analysis of mean duration from scene to hospital and data from 9 patients were excluded from the analysis of mean pre-hospital BLS duration because of missing data. Also, 12 children were excluded from the analysis of mean body weight because of missing data. The retrospective nature of this study was also a limitation. In our EDs, children who suffered OHCA and achieved sustained ROSC were quite unstable and would not stay in ED for long time. Therefore, the vital signs of patients will be routinely recorded every 10–15 min. Although, every doctors and nurses were well trained and passed the APLS examinations. There were still potentially some mistakes in recording data.

5. Conclusions

The post-resuscitative clinical features of non-traumatic OHCA children in the first hour after achieving sustained ROSC that can predict survival include sinus rhythm, a normal heart rate, normal blood pressure, and an initial urine output > 1 ml/kg/h.

Conflict of interest statement

There is no conflict of interest related to this study.

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