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Original Contribution

Factors associated with sustained return of spontaneous circulation in children after out-of-hospital cardiac arrest of noncardiac origin

Chao-Jui Li MD[a], Chia-Te Kung MD[a], Ber-Ming Liu MD[a], Chu-Chung Chou MD[b,c], Chin-Fu Chang MD[b], Tung-Kung Wu PhD[d], Tzu-An Liu PhD[d], Yan-Ren Lin MD[b,d,]*

[a]*Department of Emergency Medicine, Chang Gung Memorial Hospital-Kaohsiung Medical Center, Chang Gung University College of Medicine, Kaohsiung, Taiwan*
[b]*Department of Emergency Medicine, Changhua Christian Hospital, Changhua, Taiwan*
[c]*Institute of Medicine, Chungshan Medical University, Taichung, Taiwan*
[d]*Department of Biological Science and Technology and Institute of Biochemical Engineering, National Chiao Tung University, Hsinchu, Taiwan*

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Abstract
Purpose: The study aimed to determine the factors predictive of sustained return of spontaneous circulation (ROSC) in children with out-of-hospital cardiac arrest (OHCA) of noncardiac origin.
Methods: Eighty children were included in this retrospective study. The variables that lead to sustained ROSC and those that do not lead to sustained ROSC were analyzed. Survival analyses, including chance of achieving sustained ROSC and sum duration of ROSC, were conducted according to the duration of in-hospital cardiopulmonary resuscitation (CPR).
Results: Etiologies of noncardiac OHCA differed significantly across different age groups ($P < .001$). Only 8.8% of children had initial arrest rhythms that were shockable. Predictors of sustained ROSC included the initial cardiac rhythm ($P = .002$), a shorter period between collapse and the first chest compression ($P = .002$), a shorter in-hospital CPR duration ($P = .004$), and prehospital CPR ($P = .007$). In children where ROSC was initially sustained, those with in-hospital CPR of more than 20 minutes, ROSC was sustained for less time ($P < .001$).
Conclusions: Few children with noncardiac OHCA present with shockable cardiac rhythms. Furthermore, long-term ROSC is difficult to maintain in children who receive in-hospital CPR for more than 20 minutes.

1. Introduction

Out-of-hospital cardiac arrest (OHCA) in children is relatively uncommon and is associated with a low chance of survival [1-5]. The causes of nontraumatic OHCA in adults

* Corresponding author. Department of Emergency Medicine, Changhua Christian Hospital, 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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can be classified as cardiac or noncardiac. The major causes of OHCA of cardiac origin in adults are associated with coronary artery diseases and defibrillated rhythm. Moreover, this incidence can be decreased by primary prevention of coronary artery disease and by placement of an implantable cardiac defibrillator [6].

Pediatric nontraumatic OHCA can be either cardiac or noncardiac in origin [7,8]. Previous studies have shown that primary cardiac causes of OHCA in children include congenital heart disease, and the chance of survival is dependent on time to diagnosis and surgical intervention [1,9]. In addition, previous studies have demonstrated that prolonged cardiopulmonary resuscitation (CPR) and advanced life support medications have an impact on the ultimate prognosis in nontraumatic OHCA children [5,10]. However, the prognostic factors of sustained return of spontaneous circulation (ROSC) and the relationship between etiologies and age in children with OHCA of noncardiac origin have not been well addressed.

The purpose of this study is to determine the demographics of children with noncardiac OHCA, the different etiologies across different age groups, factors that are predictive of sustained ROSC, the initial cardiac rhythm of noncardiac OHCA, the relationship between duration of in-hospital CPR and prognosis, and the neurologic evaluation of survivors.

2. Methods

2.1. Study design

Children 18 years or younger who presented to the emergency department (ED) with OHCA of nontraumatic and noncardiac origins during the period January 2000 to January 2008 were included in this study. The information of patients was obtained according to the permission of Institutional Review Board of Chang Gung Memorial Hospital-Kaohsiung in southern Taiwan. Patient demographics and related predictive factors that may be associated with sustained ROSC in ED were recorded and analyzed.

2.2. Study setting and population

Eighty children 18 years or younger with nontraumatic and noncardiac OHCA were identified (all of them did not present spontaneous circulation when arrived hospital) and their medical records reviewed. Children presented to the ED at either the Chang Gung Memorial Hospital-Kaohsiung in southern Taiwan (a medical center with 2500 beds) or the Changhua Christian Hospital in central Taiwan (a medical center with 2000 beds). The organization of local public emergency medical systems and the training of emergency medical services (EMS) personnel are similar in both southern and central Taiwan. The majority management of resuscitation by EMS personnel was according to the basic life support (BLS) protocol. In each case, the ambulance crew consisted of 2 EMS personnel who went to the scene immediately after having received an emergency call. The average response time to cardiopulmonary arrest is commonly within 5 minutes, whereas the transport time is within 10 minutes. All EMS personnel are required to undergo at least 60 hours of emergency medical technician (EMT) training and are classified according to the number of hours they received: EMT-1, 60 hours of training; EMT-2, 264 hours of training; and EMT-P, 1280 hours of training. The resuscitation procedures include chest compression, use of automated external defibrillator, and use of noninvasive ventilation, such as a Bag-Valve-Mask. The setup of a definitive airway (ie, oral or nasal endotracheal intubation) is only done by EMT-P personnel. The EMS personnel always perform continuous chest compression CPR from the scene to the hospital in all patients who experienced cardiac arrest. Also, EMT personnel receive and follow medical commands from ED physicians if there is any difficulty during resuscitation. In addition, only ED physicians are permitted to decide whether resuscitation efforts should be discontinued. The decision of stop resuscitation is made only after a detailed clinical assessment indicates that achieving successful resuscitation is not possible. The order "Do Not Resuscitate" is only enforced in the hospital, not in the ambulance.

Patients were divided into 6 groups based on the possible etiology of the OHCA: (1) sudden infant death syndrome; (2) various infections (including upper and lower respiratory tract infections, urinary tract infection, deep neck infection, infective colitis, and enterovirus); (3) neurologic deficits (including status epilepticus, spontaneous intracranial hemorrhage, and hydrocephalus); (4) asphyxia (acute or chronic respiratory failure, food bolus or foreign body obstruction, and spontaneous tension pneumothorax); (5) malignancy (leukemia, etc); (6) idiopathic causes. Classification of etiology was based on a detailed history (from families and/or witnesses), clinical assessment, laboratory investigations, and radiologic examinations. The detailed hospital records not only included clinical findings recorded by the ED physicians and/or nurses but also included collateral histories from family members, details relating to underlying diseases and medical history, results from pathologic specimen analysis, and radiologist reports. Etiologies that were unclear were classified as idiopathic causes.

2.3. Study protocol

Information relating to the prehospital phase of resuscitation and BLS, including location of cardiac arrest, time between collapse and the first chest compression, and the duration of prehospital CPR (the sum duration of CPR that the patient had received before arriving at the hospital), was obtained from public emergency medical services records and witness statements. Children with OHCA received resuscitation according to the advanced pediatric life support protocol in both centers. The protocols adhered to the pediatric Utstein reporting system [11]. Demographic data gathered from the ED patient charts included initial vital signs, age, sex, initial cardiac rhythm on presentation to the ED, duration of in-hospital CPR (CPR after ED arrival and in fact is advanced pediatric life support care), body weight, body temperature, medications administered during CPR, and the sum of duration of ROSC, which was defined as the period from the time the patient achieved in-hospital sustained ROSC to death or discharge from hospital. In this study, the initial cardiac rhythm on presentation to ED was recorded as an electrocardiogram that was recorded immediately on arrival. Abnormal rhythms included ventricular fibrillation (VF) and pulseless ventricular tachycardia, pulseless electrical activity (PEA), and asystole. Patients were divided into 6 groups according to age: newborn (<1 month), infant (1 month to 1 year), toddler (1-3 years), preschool (4-5 years), school age (6-12 years), and adolescent (13-18 years), and then the relationship between these groups and the possible causes of OHCA was analyzed. Overall, all treatments and decisions regarding the termination of resuscitation efforts were made at the discretion of the treating physician.

In our study, sustained ROSC was deemed to have occurred when chest compressions were not required for a period of 20 consecutive minutes and signs of a circulation were evident [12]. Prehospital information, demographic data, etiology, duration of in-hospital CPR, and medications administered during CPR were all analyzed for their influence on sustained ROSC in children with noncardiac OHCA. Children who achieved sustained ROSC were admitted to the pediatric intensive care unit, and their outcomes were analyzed for identifiable prognostic factors. Time-related survival analyses, including the chance of achieving sustained ROSC in ED and ultimate sum duration of ROSC, were calculated for patients receiving different durations of in-hospital CPR (<10, 11-20, 21-30, and >30 minutes). The neurologic functions of children who survived to discharge were evaluated before cardiac arrest (baseline), at the time of discharge from the hospital, and at 3 months after discharge according to Pediatric Cerebral Performance Category Scale (PCPCS) [13].

2.4. Data analysis

Data were analyzed according to the χ^2 test, Fisher exact test, Mann-Whitney *U* test, and stepwise logistic regression analysis. The results of descriptive analyses of independent variables (age, sex, prehospital information, duration of in-hospital CPR, medication dosage, and total duration of ROSC) were reported as percentages and the mean average ± SD. Factors that may be associated with a sustained ROSC were analyzed according to Fisher exact test and the Mann-Whitney *U* test. A stepwise logistic regression analysis was used to select independent predictors of the dichotomous dependent variables, sustained ROSC and nonsustained ROSC. The statistical significance of relationships between different etiologies and age groups were analyzed by the χ^2 test, as were results relating to survival (sustained ROSC and duration of ROSC). A *P* value of less than .05 was regarded as statistically significant.

Table 1 Demographics, etiology, and resuscitation techniques used in pediatric patients with OHCA of noncardiac origin

	Children with noncardiac OHCA (n = 80)	
	No.	%
Age (mean ± SD) (y)	4.43 ± 5.80	
Newborn	11	13.8
Infant	29	36.3
Toddler	11	13.8
Preschool	8	10.0
School	9	11.3
Adolescent	12	15.0
Sex		
Male	44	55.0
Female	36	45.0
Place of cardiac arrest		
Home	72	90.0
Outside home	8	10.0
Sustained ROSC [a]		
Yes	21	26.3
No	59	73.8
Survival to discharge		
Yes	6	7.5
No	74	92.5
Possible etiology		
Sudden infant death syndrome	17	21.3
Various infections	15	18.8
Neurologic deficits	15	18.8
Asphyxia	25	31.3
Malignancy	3	3.8
Idiopathic causes	5	6.3
Initial cardiac rhythm		
Asystole	62	77.5
PEA	11	13.8
VF	7	8.7
Duration of prehospital BLS (mean ± SD) (min)	19.19 ± 17.25	
Time between collapse and first chest compression (mean ± SD) (min)	13.38 ± 10.13(5) [b]	
Duration of in-hospital CPR (mean ± SD) (min)	34.23 ± 20.67	
Epinephrine injections (mean ± SD) (times)	7.59 ± 4.62	
Epinephrine total dose (mean ± SD) (mg/kg)	0.38 ± 0.43	
Body temperature (mean ± SD) (°C)	34.31 ± 1.68	
Body weight (mean ± SD) (kg)	15.61 ± 15.08 (4) [b]	

[a] ROSC of 20 minutes or more.
[b] Number of patients with missing information.

3. Results

3.1. Demographics, etiologies, and outcomes

We identified 80 children in total with OHCA of noncardiac origin. There were 44 boys and 36 girls. The mean age was 4.43 ± 5.80 years. Most children were in the infant group (n = 29; 36.3%), followed by the adolescent group (n = 12; 15%), the newborn group (n = 11; 13.8%), the toddler group (n = 11; 13.8%), the school-aged group (n = 9; 11.3%), and then the preschool-aged group (n = 8; 10.0%). The most common location where cardiac arrest occurred was at home (90%). Sustained ROSC was achieved in 21 children (26.3%), but only 6 survived and were eventually discharged home. The overall mortality rate was 92.5% (74/80 patients) (Table 1).

The mean duration of prehospital BLS was 19.19 ± 17.25 minutes, and the mean period between collapse and the first chest compression was 13.38 ± 10.13 minutes. The most common presenting cardiac rhythm was asystole (76.3%), followed by PEA (13.8%) and then VF (8.8%). The mean body weight of children was 15.61 ± 15.08 kg, and the mean body temperature was 34.31 ± 1.68°C. During in-hospital resuscitation, the mean number of epinephrine injections was 7.59 ± 4.62 and the mean total dose of epinephrine was 0.38 ± 0.43 mg/kg. The most common cause of noncardiac origin OHCA was asphyxia (31.3%), followed by sudden infant death syndrome (21.3%), various infections (18.8%), neurologic deficits (18.8%), idiopathic causes (6.3%), and malignancy (3.8%) (Table 1).

3.2. Analysis of etiologies of OHCA in different age groups

Overall, asphyxia was the most common cause of OHCA, but sudden infant death syndrome was the predominant etiology in newborns (54.5%) and infections was the most common etiology in toddlers (54.5%). Moreover, we found that the etiologies differed significantly between these 6 age groups ($P < .001$) (Fig. 1). As the name implies, sudden infant death syndrome was a factor only in the newborn and infant groups (54.5% in newborns and 44.8% in infants). Infections were more common in children older than infants (9.1% in newborns and 3.4% in infants; 54.5% in toddlers; 25% in preschool-aged children, 33.3% in school-aged children, and 16.7% in adolescents). Neurologic deficits were more predominant in toddlers and preschool-aged children (9.1% in newborns, 10.3% in infants, 36.4% in toddlers, 57.1% in preschool-aged children, 11.1% in school-aged children, and 16.7% in adolescents).

3.3. Factors related to sustained ROSC

Sustained ROSC was achieved in 21 (26.3%) of 80 children with OHCA of noncardiac origin after initial in-hospital CPR. Sustained ROSC was related to initial cardiac rhythm (P = .002), duration of prehospital BLS (P = .007), time between initial collapse and first chest compression (P = .002), and duration of in-hospital CPR (P = .004) with statistical significance. The mean duration of prehospital BLS was 8.29 ± 4.50 minutes in patients with sustained ROSC and 24.22 ± 23.45 minutes in patients without sustained ROSC (P = .007). The time between initial collapse and the first chest compression was 4.33 ± 2.42 minutes in patients with sustained ROSC and 16.61 ± 14.72 minutes in patients without sustained ROSC (P = .002). The mean duration of in-hospital CPR was 14.10 ± 9.81 minutes in patients with sustained ROSC and 38.68 ± 15.50 minutes in patients without sustained ROSC (P = .004). Factors that were not significantly related to sustained ROSC included sex (P = 1.000), age (P = .840), location of cardiac arrest (P = .091), possible etiology (P = .461), epinephrine total

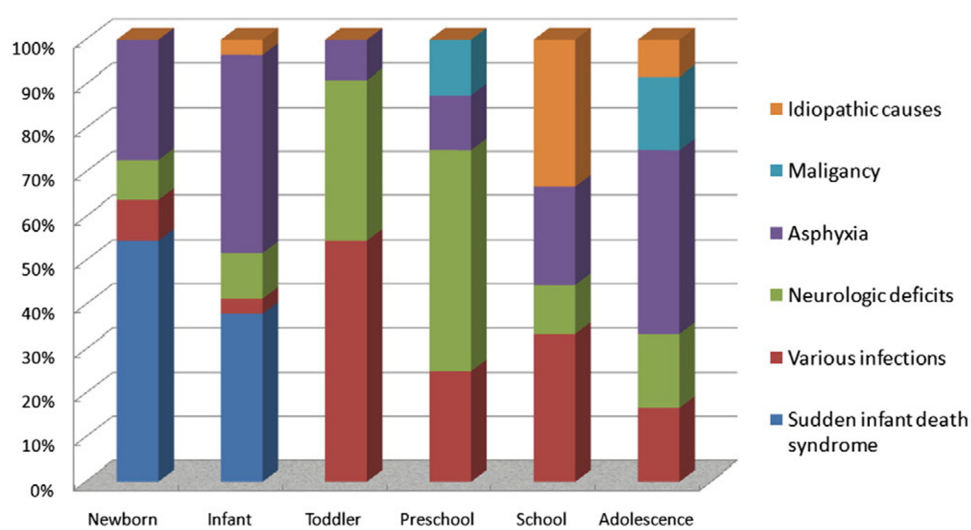

Fig. 1 The etiologies of noncardiac OHCA differed significantly between the 6 age groups ($P < .001$) (newborn: n = 11; infant: n = 29; toddler: n = 11; preschool: n = 8; school: n = 9; adolescence: n = 12).

dose (P = .245), body temperature (P = .326), body weight (P = .917), and mean number of epinephrine injections (P = .359) (Table 2).

Multivariate logistic regression analysis revealed that initial cardiac rhythm (P = .038), time between initial collapse and first chest compression (P < .001), and duration of in-hospital CPR (P < .001) correlated most strongly with sustained ROSC. The rate of achieving sustained ROSC was higher in children with PEA (P = .004) and VF (P = .034) than in children with asystole (Table 3).

Table 2 Factors associated with sustained ROSC in pediatric patients with OHCA of noncardiac origin

	Pediatric patients with noncardiac OHCA (n = 80)		
	Sustained ROSC [a]		P
	Success	Failure	
Sex			
Male	14	30	1.000
Female	7	29	
Age			
Newborn	4	7	.840
Infant	6	23	
Toddler	4	7	
Preschool	2	6	
School	3	6	
Adolescent	2	10	
Place of cardiac arrest			
Home	14	58	.091
Outside home	7	1	
Possible etiology			
Sudden infant death syndrome	4	13	.461
Various infections	6	9	
Neurologic deficits	4	11	
Asphyxia	7	18	
Malignancy	0	3	
Idiopathic causes	0	5	
Initial cardiac rhythm [b]			
Asystole	10	52	.002
PEA	7	4	
VF	4	3	
Duration of prehospital BLS [b] (mean ± SD) (min)	8.29 ± 4.50	24.22 ± 23.45	.007
Time between collapse and first chest compression [b] (mean ± SD) (min)	4.33 ± 2.42	16.61 ± 14.72	.002
Duration of in-hospital CPR [b] (mean± SD) (min)	14.10 ± 9.81	38.68 ± 15.50	.004
Epinephrine injections (mean ± SD) (times)	4.53 ± 3.02	8.77 ± 6.01	.359
Epinephrine total dose (mean± SD) (mg/kg)	0.22 ± 0.24	0.42 ± 0.46	.245
Body temperature (mean ± SD) (°C)	35.06 ± 1.50	34.14 ± 1.70	.326
Body weight (mean ± SD) (kg)	16.97 ± 16.41	15.28 ± 15.03	.917

[a] ROSC of 20 minutes or more.
[b] Predictive factors associated with sustained ROSC.

Table 3 Multivariate logistic regression analysis of the factors associated with sustained ROSC in children with noncardiac OHCA

	SE	OR	95% CI	P
Initial cardiac rhythm				.038
PEA	0.92	6.84	1.54-32.19	.004 **
VF	1.02	9.57	1.27-93.44	.034 *
Time between collapse and first chest compression	0.61	1.53	0.96-1.78	<.001
Duration of in-hospital CPR	0.04	0.89	0.83-0.95	<.001

CI indicates confidence interval; OR, odds ratio.
* P = .034 for the comparison between asystole and VF.
** P = .004 for the comparison between asystole and PEA.

3.4. Likelihood of achieving sustained ROSC in the ED and continued survival according to duration of in-hospital CPR

Twenty-one children who achieved sustained ROSC initially were arranged into groups according to the duration of in-hospital CPR received (<10 minutes, 11-20 minutes, 21-30 minutes, and >30 minutes; the number of patients were 9, 7, 4, and 1, respectively). We found that the duration of CPR was less than 20 minutes in 76.2% (n = 16) of children who achieved sustained ROSC. Furthermore, the rate of achieving sustained ROSC decreased as the duration of in-hospital CPR increased (P < .001) (Fig. 2A). The mean duration of sustained ROSC was longer in children warranting a shorter duration of in-hospital CPR, particularly when the duration of CPR was less than 20 minutes (P < .001) (Fig. 2B).

The outcomes of the 6 children who survived to discharge are shown in Table 4. The etiologies of OHCA were idiopathic (n = 1), epilepsy (n = 1), pneumonia (n = 2), and suffocation (n = 2). The initial cardiac rhythm was asystole in one patient and either PEA or VF in the others. All 6 children received chest compression within 6 minutes from the onset of collapse; the total duration of CPR (prehospital plus in-hospital) was within 25 minutes and the duration of in-hospital CPR was within 15 minutes. Furthermore, there was no change in PCPCS score before cardiac arrest and at discharge in 2 children; 1- or 2-category deterioration in neurologic function was noted in the others. Of the 6 survivors, one child was discharged with mild disability (PCPCS score = 2), 3 were discharged with moderate disability (PCPCS score = 3), and 2 were discharged with severe disability (PCPCS score = 4) or in a vegetative state (PCPCS score = 5). Among the survivors, 2 children died of

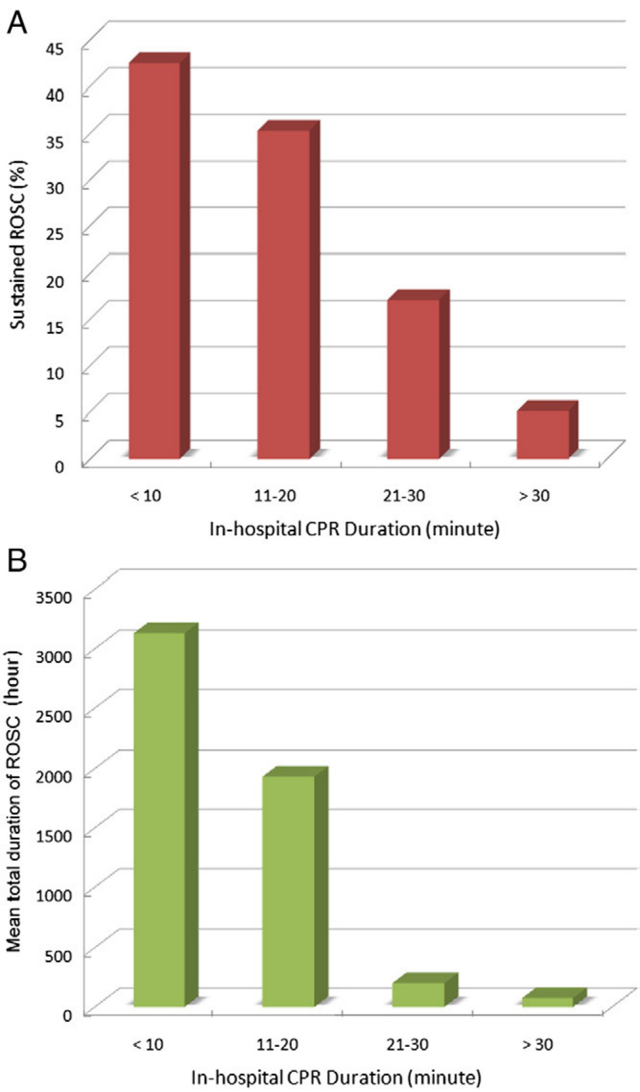

Fig. 2 Analysis of the relationship between duration of in-hospital CPR and (A) likelihood of achieving sustained ROSC ($P < .001$) and (B) mean total duration of ROSC ($P < .001$).

recurrent respiratory tract infections. The other 4 children had no improvement or deterioration in PCPCS score at 3-month follow-up.

4. Discussion

Cardiopulmonary resuscitation in children with OHCA poses a difficult challenge to primary physicians because the rate of survival is very low [7-9,14,15]. Nontraumatic OHCA in children can be either cardiac or noncardiac in origin [7,8]. The outcomes of resuscitation in patients with OHCA of noncardiac origin have been studied in adults but not be well addressed in children [6]. In addition, the causes of noncardiac OHCA in children and the associated predictive factors of sustained ROSC remain unclear. Furthermore, there have been few studies on the time-related factors that might be associated with outcomes, including the durations of prehospital or in-hospital CPR and the time between collapse and first chest compression [16].

In this study, we have analyzed the relationship between different age groups and causes of noncardiac OHCA, the factors associated with sustained ROSC, and the relationship between duration of in-hospital CPR and duration of sustained ROSC.

In this study, OHCA was most common in infants and then adolescents. Overall, the most common etiology was asphyxia and then sudden infant death syndrome. The causes of OHCA in children in our study differ markedly from those identified in adults according to Hess and colleagues [6]. In their study of 90 adult patients with OHCA of noncardiac origin, the most common etiologies were respiratory failure, idiopathic causes, and pulmonary embolism. In addition, other studies have previously reported that the clinical diagnosis made in children with OHCA correlated less well in nontraumatic than traumatic scenarios [8]. However, the diagnoses made by physicians in children with nontraumatic OHCA were still critically important and guided clinical treatment strategies in children who were revived in the ED after primary resuscitation. Although etiology was sometimes initially unclear in the ED, some factors identified in this study may guide clinicians treating such children. In this study, we found that the causes for OHCA differed significantly between age groups ($P < .001$). Sudden infant death syndrome was the major cause of OHCA in newborns and infants (54.5% in newborns and 44.8% in infants).

Table 4 Neurologic functions in children who experienced noncardiac OHCA and survived to discharge

Children who had noncardiac OHCA and survived to discharge (n = 6)									
Patient no.	Age (y)	Sex	Etiology	Initial cardiac rhythm	Time between collapse and first chest compression (min)	Duration of pre/in-hospital CPR (min)	PCPCS		
							Baseline	Discharge	Three months after discharge
1	15	M	Pneumonia	Asystole	4	8/1	4	5	Dead
2	0.25	F	Pneumonia	PEA	2	5/7	1	3	3
3	0.04	M	Suffocation	VF	6	4/9	1	2	2
4	1.17	F	Idiopathic	PEA	3	4/15	1	3	3
5	10	M	Epilepsy	PEA	3	6/4	3	3	3
6	6	M	Suffocation	VF	4	12/13	4	4	Dead

Infections was more common in older than in younger children, and neurologic deficits were more predominant in toddler and preschool-aged children. According to these results, we suggest that the age of the child could be an important clue in identifying different possible etiologies during or after resuscitation in children with noncardiac OHCA, especially when the clinical presentation is non-specific or collateral history is lacking. For example, an infectious cause should be suspected in older children who present with OHCA. These patients should therefore undergo a sepsis workup to survey the source of infection. In addition, neurologic deficits should be suspected in toddlers and preschool-aged children who present with OHCA. Imaging studies of the central nervous system, such as brain computed tomography scan, should be arranged to rule out spontaneous intracranial hemorrhage or hydrocephalus.

The initial cardiac rhythm on presentation to ED in children with nontraumatic OHCA varies across different studies but was reported to be shockable in approximately 10.2% to 19% [3,15-17]. However, in this study, we found that only 8.7% were shockable rhythms and was therefore somewhat lower. The multivariate logistic regression analysis in this study also identified that children presenting with PEA and VF as initial cardiac rhythms had a higher chance of achieving sustained ROSC than those children in asystole. Therefore, we not only emphasize the importance of prolonged and high-quality prehospital and/or in-hospital CPR but also suggest that cardiac rhythm analysis should be performed as soon as possible because the resuscitation strategies differ across the different rhythms.

Time-related factors seemed to influence the outcomes of CPR in children with noncardiac OHCA in our study. Two important factors were the time between initial collapse and first chest compression and the duration of in-hospital CPR. It was noted that as the period between collapse and first chest compression became shorter, the chance of achieving sustained ROSC in ED increased. In this study, we noted that 90% of children with OHCA collapsed at home and were found by family members. Therefore, to elevate the chance of achieving sustained ROSC in ED, we suggest that chest compressions should be commenced by family members and therefore educational courses in basic CPR training would be invaluable to parents.

The finding that shorter periods of in-hospital CPR are significantly associated with sustained ROSC has been reported in other studies [4,5], but they do not mention the actual duration of CPR that resulted in the chance of sustained ROSC in ED initially and the duration of ROSC in these children with noncardiac OHCA. In our study, we analyzed these relationships and found that most of the children who achieved sustained ROSC did so within 20 minutes. We also found that as the duration of CPR increased, the chance of sustained ROSC significantly decreased ($P < .001$). Furthermore, among the children who initially achieved a sustained ROSC in the ED, those who received in-hospital CPR for more than 20 minutes had a shorter duration of sustained ROSC ($P < .001$). In fact, the duration of in-hospital CPR did not exceed 20 minutes in any of the children who survived to discharge. According to our study, fewer children with noncardiac OHCA presented with shockable cardiac rhythm and children who received in-hospital CPR for more than 20 minutes had difficulty in maintaining long-term ROSC.

4.1. Limitations

There were some limitations to this study. To our knowledge, patients who experience an OHCA but who do not present with neurologic deficits are prime candidates for cardiac resuscitation. However, the survival rate in this study was very low. All OHCA children received resuscitation in the ED, but most of them died. However, these OHCA children who achieved a return to spontaneous circulation after primary resuscitation received further treatment or critical care in the ICU. Identifying the factors associated with sustained ROSC may offer primary clinicians more information to make correct evaluations and decisions and increase the chances of functional survival. Even if the overall and functional survival rate were very poor in the OHCA children now, increasing the sustained ROSC rate will advance the survival rate when the critical care progresses in the future. The retrospective nature of this study was another limitation. Furthermore, 3 patients were excluded because illegible hospital records made it difficult to follow them. The overall rate of sustained ROSC was 26.3% in this study. However, this rate may actually be higher because a few parents felt resuscitation would be hopeless and treatment was withheld before adequate resuscitation is performed. Four children with underlying diseases and with an order of “Do Not Resuscitate” before their cardiac arrest were not included in this study. According to the “Do Not Resuscitate” order, the resuscitation will not be performed or will be interrupted by ED physicians. Moreover, this study demonstrated that the different forms of cardiac rhythm on initial presentation to the ED are indicative of the different chances of achieving sustained ROSC. The low incidence of PEA and VF may reflect prolonged transportation times. A prehospital cardiac rhythm analysis would be useful, but this information was commonly lacking in younger children. This was especially true in newborns and infants, when automated external defibrillator assessments were uncommon. We hope that this topic could be further investigated in the future with a prospective study.

5. Conclusions

The causes of noncardiac OHCA differ significantly across children of different age groups. Sudden infant death syndrome was the major cause of OHCA in newborns and infants, whereas infections were more common in older children and neurologic deficits affected mostly toddlers and preschool-aged children. Sustained ROSC would be more likely achieved in children with a shorter period between collapse and the commencement of chest compressions and a shorter duration of in-hospital CPR. Most importantly, we found that very few children with noncardiac OHCA presented to ED with shockable cardiac rhythms and that in-hospital CPR lasting more than 20 minutes may initially establish a return to spontaneous circulation but that the sum duration of ROSC can be very short.

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