Outcome of Out-of-Hospital Cardiorespiratory Arrest in Children

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Objective: To analyze the characteristics and outcome of out-of-hospital cardiorespiratory arrest in children in Spain.

Methods: Secondary analysis of data from a prospective, multicenter study analyzing cardiorespiratory arrest in children. Ninety-five children between 7 days and 16 years with cardiorespiratory arrest. Data were recorded according to the Utstein style. The outcome variables were the sustained return of spontaneous circulation (initial survival), and survival at 1 year (final survival). Neurologic and general performance outcome was assessed by the Pediatric Cerebral Performance Category (PCPC) scale and the Pediatric Overall Performance Category (POPC) scale.

Results: Initial survival was 47.3% and 1-year survival was 26.4%. Mortality was higher in children younger than 1 year. Survival of patients with respiratory arrest (82.1%) was significantly higher than survival of cardiac arrest victims (14.4%). Patients who were initially resuscitated by laypersons or paramedics had higher survival (53.6%) than those who were initially resuscitated by doctors and/or nurses (15.2%) ($P < 0.01$). Mortality was higher in the patients who presented slow rhythms (asystole, severe bradycardia) or pulseless electrical activity than in those presenting ventricular fibrillation ($P = 0.001$). Multivariate logistic regression revealed that the best indicator of mortality was duration of cardiopulmonary resuscitation longer than 20 minutes. After 1 year, most survivors had normal or mild disability.

Conclusions: Mortality of out-of-hospital cardiorespiratory arrest in children is high. When resuscitation is started soon by layperson or paramedics, survival is increased. Duration of resuscitation efforts is the best indicator of mortality. Most of survivors had good long-term neurologic outcome.

Key Words: resuscitation, out-of-hospital cardiorespiratory arrest, cardiopulmonary resuscitation

In adults, out-of-hospital cardiorespiratory arrest (CRA) causes, characteristics, and evolution are clearly different from in-hospital CRA,[1,2] and its mortality is significantly higher.[3] In one study, children with out-of-hospital CRA had an overall lower rate of survival than adults arrested in a similar scenario.[4] However, up to now, few prospective studies have analyzed the causes, risk factors, and outcome of out-of-hospital CRA in children.[4–6] Moreover, comparison of the different series is complicated because many were retrospective,[7–10] or included a small number of patients, or used different definitions and methods of data analysis.[7–11] Some studies included also patients diagnosed and resuscitated at the Hospital Emergency Department,[8,12] whereas others selected only patients in whom cardiopulmonary resuscitation (CPR) was performed out-of-hospital.[4–6,10] The Utstein style provides uniform guidelines for reporting characteristics and outcome for out-of-hospital CRA in children.[13] To date, no prospective study analyzing the outcome of out-of-hospital CRA in children following the Utstein style guidelines has been reported; therefore, the objective of the present study was to provide an Utstein style prospective and multicenter report of pediatric out-of-hospital CRA, to evaluate factors associated with mortality, and to know the long-term outcome of survivors.

METHODS

An invitation to participate in the study was sent to all the out-of-hospital Emergency Medical Systems (EMS), Pediatric Intensive Care Units (PICU), and Pediatric Departments in Spain.[14] A protocol was drawn up in accordance with the Utstein style guidelines.[13] The present study is a secondary analysis of data from a research of pediatric cardiopulmonary arrest in Spain; the methodology and primary results of which have been described elsewhere.[15] Patients aged from 7 days to 18 years who suffered CRA and received CPR out-of-hospital from April 1998 to September 1999 were analyzed. Patients who suffered a CRA out-of-hospital but were diagnosed and/or initially treated at hospital were excluded. Respiratory arrest was defined as the absence of respiration requiring assisted ventilation at the moment of arrest recognition, and cardiac arrest was defined as the inability to palpate a central pulse, unresponsiveness, and apnea or severe bradycardia lower than 60 bpm with poor perfusion in infants requiring external cardiac compressions and assisted ventilation.[13] A record was made that included: patient-related variables (age, sex, weight, cause of the arrest, existence of a previous arrest, family and personal background), arrest and life support–related variables (type of arrest, location of the arrest, time elapsed from the arrest

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TABLE 1. Pediatric Cerebral Performance Category Scale

Scale	Category	Description
1	Normal	Normal: at age-appropriate level; school-age child attending regular school classroom.
2	Mild disability	Conscious, alert, and able to interact at age-appropriate level; school-age child attending regular school classroom but grade perhaps not appropriate for age; possibility of mild neurologic deficit (eg, seizure disorder).
3	Moderate disability	Conscious. Below age-appropriate functioning; neurologic disease that is not controlled and severely limits activities. Sufficient cerebral function for age-appropriate independent activities of daily life; school-age child attending special education classroom and/or learning deficit present.
4	Severe disability	Conscious; dependent on others for daily support because of impaired brain function. School-age child may be so impaired as to be unable to attend school.
5	Coma or vegetative state	Any degree of coma without the presence of all brain death criteria unawareness, even if awake in appearance, without interaction with environment; cerebral unresponsiveness and no evidence of cortex function (not roused by verbal stimuli); possibility of some reflexive responsive, spontaneous eye-opening, and sleep-wake cycles.
6	Brain death	Apnea, arreflexia, and/or electroencephalographic silence.

to starting of CPR, persons who performed the CPR life support maneuvers and procedures, first ECG rhythm, and total duration of CPR), outcome-related variables: (a) initial survival, defined as the return of spontaneous circulation (ROSC) intermittent or maintained for more than 20 minutes; (b) return of spontaneous breathing; (c) CPR attributable complications; (d) neurologic status at the end of the CPR; (e) later complications (in the PICU): respiratory (defined as need for assisted ventilation for more than 48 hours after the arrest due to respiratory causes), shock (defined as an systolic blood pressure 3 standard deviations below the normal for the patient's age and/or the need for volume expansion greater than 20 mL/kg and/or the administration of vasoactive drugs (dopamine >15 μg/kg/min or adrenaline or noradrenaline >0.2 μg/kg/min), renal failure (creatinine greater than 2 times the upper limit of normal for the patient's age or the need for renal replacement therapy), nosocomial infection (according to the criteria of the Center for Disease Control), intracranial hypertension (intracranial pressure greater than 20 mm Hg); and (f) cause and time of death. The cerebral status was assessed at PICU discharge, at hospital discharge, at 1-year follow-up by means of the Glasgow-Pittsburg (PCPC) score (Table 1), and general status by means of the Overall Performance Categories (POPC) scale (Table 2), a 6-point scale comprising the following categories: 1 = normal or good; 2 = mild disability; 3 = moderate disability; 4 = severe disability; 5 = coma or vegetative state; and 6 = brain dead.[13]

The statistical study was performed using the SPSS (version 12) software statistical program. Pearson's χ^2 test was used for qualitative variables analysis, and Fisher exact test was used when n was less than 20 or when any value was less than 5. Student *t* test was used to compare quantitative variables between independent groups and the Mann-Whitney *U* test for variables not normally distributed. Multivariate logistic regression was performed to assess the influence of each one of the factors on the initial mortality (nonsustained ROSC), the mortality at hospital discharge,

TABLE 2. Pediatric Overall Performance Category (POPC)

Scale	Category	Description
1	Good	PCPC normal. Normal age-appropriate activities; medical and physical problems do not interfere with normal activity.
2	Mild disability	PCPC mild, minor chronic physical, or other medical problems present minor limitations but are compatible with normal life; preschool-age child has physical disability consistent with future independent functioning an can perform more than 75% of age-appropriate activities of daily living.
3	Moderate disability	PCPC moderate; medical and physical conditions are limiting, preschool-age child cannot perform most age-appropriate activities of daily living; school-age child can perform most activities of daily living but is physically disabled.
4	Severe disability	PCPC severe; preschool-age child cannot perform most age-appropriate activities of daily living: school-age child is dependent on others for most can activities of daily living.
5	Coma or vegetative responsive	PCPC coma/vegetative state.
6	Death	

and final mortality (at 1 year). All individual factors with statistically significance in the univariate analysis were included in the multivariate analysis. A *P* value less than 0.05 was considered significant. The data of the hospital discharge survival and final survival were very similar, and therefore, only the final survival data are presented.

RESULTS

From April 1, 1998 to September 30, 1999, 283 children in CRA were studied. Ninety-five patients, 61 boys (64%) and 34 girls (36%), suffered out-of-hospital CRA and were selected for analysis in this study. The mean age of patients was 63.2 ± 59.1 months (range 7 days to 16 years) and mean weight was 21.8 ± 16.8 kg (3 to 65 kg). Characteristics of the patients and CRA as well as initial and final mortality are summarized in Table 3 and Figure 1.

After initial resuscitation attempts, ROSC was achieved in 68 patients (71.5%), but only in 45 was the ROSC sustained (that means 47.3% initial survival). Eighteen patients with sustained ROSC died later in the hospital (9 in the first 24 hours after CRA, 6 between 1 and 7 days, and 3 after 7 days) and another 2 died after hospital discharge. One-year survival was 26.4%. The cause of death

TABLE 3. Characteristics of Cardiorespiratory Arrest and Survival

	No. Patients	Initial Mortality (%)	Final Mortality (%)	Relative Risk of Final Mortality	95% CI	*P*
Age						
<1 month	2	50	50	0.68	0.17–2.74	NS
1–12 months	23	73.9	91.3	1.34	1.1–1.64	<0.05
1–8 years	46	50	65.2	0.82	0.64–1.05	NS
>8 years	95	52.6	72.6	1.04	0.79–1.37	NS
Gender						
Female	34	41.2	64.7	0.84	0.63–1.11	NS
Male	61	59	78.6	1.22	0.92–1.6	NS
Diagnosis						
Respiratory disease	14	35.7	50	0.64	0.38–1.09	NS
Heart disease or arrhythmia	9	55.6	88.9	1.25	0.96–1.63	NS
Neurologic disease	13	61.5	92.3	1.33	1.07–1.64	<0.05
Trauma*	11	63.6	90.9	1.29	1.03–1.63	<0.05
Drowning	24	37.5	54.2	0.69	0.47–1.01	NS
Foreign-body airway obstruction	3	0	33.3	0.45	0.09–2.24	NS
Infectious	2	50	50	0.68	0.17–2.74	NS
SIDS	12	91.7	100	1.46	1.26–1.48	<0.05
Other	4	50	75	1.03	0.58–1.84	NS
Unknown	3	66.7	100	1.39	1.23–1.58	<0.05
Type of arrest						
Respiratory	17	5.9	17.6	0.21	0.07–0.57	<0.05
Cardiac	78	62.8	85.9	7.30	1.98–26.92	<0.05
Site of arrest						
Home	26	57.7	73.1	1.01	0.77–1.32	NS
Public place	69	50.7	73.9	1.01	0.77–1.32	NS
Cardiac rhythm						
Asystole/bradycardia/atrioventricular block	61	68.9	90.1	2.1	1.14–3.87	<0.05
Ventricular fibrillation/tachycardia	9	22.2	77.8	0.95	0.66–1.37	NS
Asystole	50	74	94	1.68	1.18–2.39	<0.05
Supraventricular bradycardia	5	20	60	0.71	0.35–1.46	NS
Ventricular bradycardia	2	100	100	1.24	1.11–1.38	<0.05
Pulseless electrical activity	4	50	75	0.92	0.52–1.63	NS
Ventricular fibrillation	9	22.2	77.8	0.95	0.66–1.37	NS
Sinus rhythm	4	0	0	0	—	—

Initial mortality: nonsustained ROSC to CPR initial attempts.
Final mortality: mortality at 1 year.
*Isolated head injury has been classified as neurological disease.

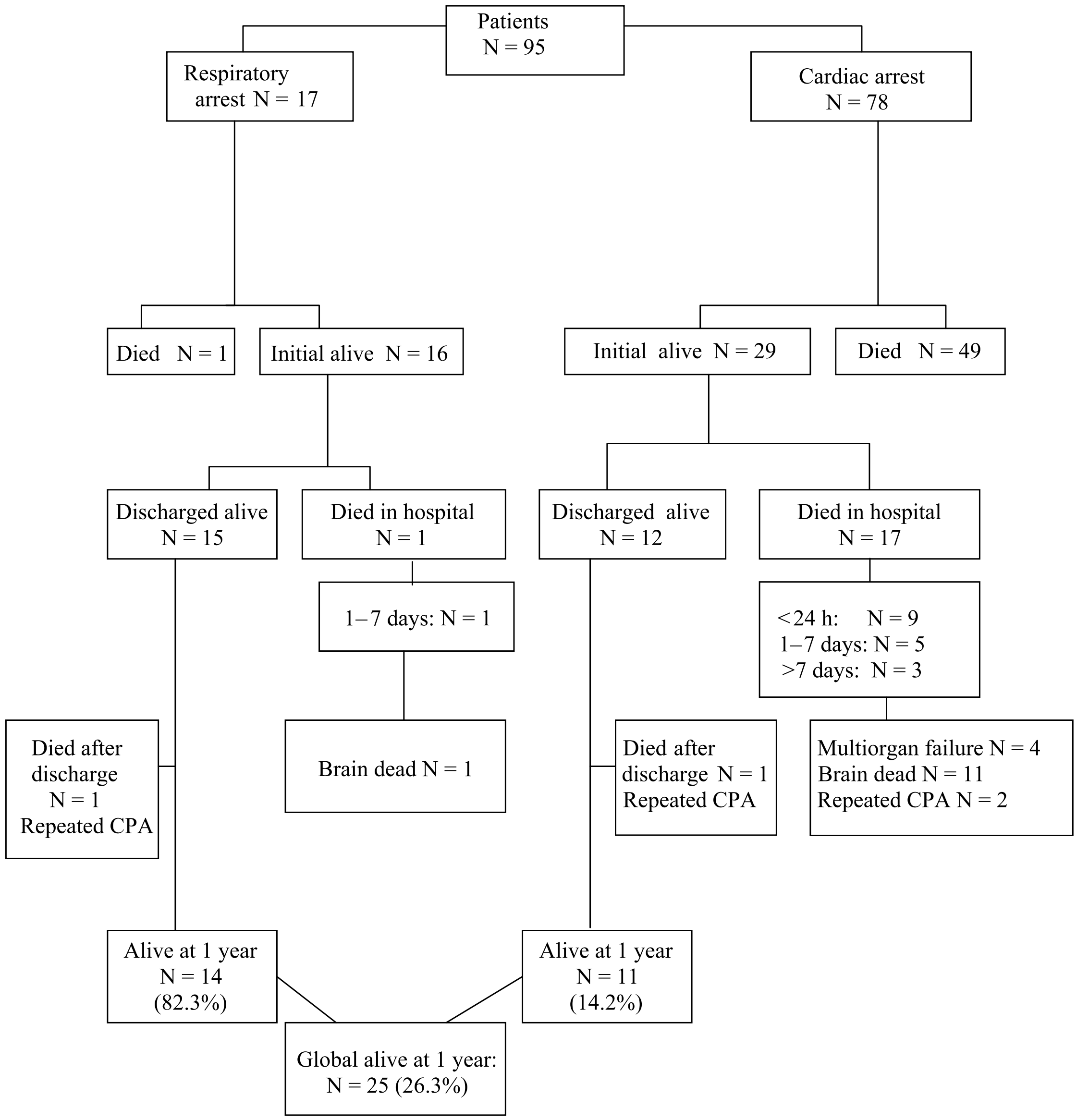

FIGURE 1. Pediatric Utstein template for recording outcome from cardiopulmonary arrest.

was nonresponse to CPR attempts in 50 patients (71.4%), brain death in 12 (17.1%), multiorgan failure in 4 (5.7%), and nonresponse to CPR attempts in a new CRA event in 4 (5.7%) (Fig. 1).

Mortality of patients aged between 1 and 12 months was significantly higher than in patients older than 1 year (Table 1). Survivors and nonsurvivors were not different in terms of sex or weight. CRA occurred in a public place in 69 patients (72.6%) and at home in 26 (27.3%); mortality was similar in both sites.

At the time of arrest recognition, 17 patients (17.9%) presented respiratory arrest and 78 (82.1%) cardiac arrest. Seven patients with initial respiratory arrest developed cardiac arrest during resuscitation and required cardiac massage; 3 of them required also epinephrine. Initial and final mortality of respiratory arrest cases was significantly lower than cardiac arrest cases ($P < 0.0001$) (Table 1). The etiology of arrest is summarized in Table 3. Patients with sudden infant death syndrome, neurologic disease, or trauma had higher mortality than children with other arrest etiologies (Table 3).

An ECG was recorded at the time of EMS arrival in 74 patients (77.9%). Slow rhythms were present in 77%, pulseless electrical activity in 5.4%, ventricular fibrillation in 12.1%, and sinus rhythm in 5.2%. Initial and final survival was lower in those patients with slow rhythms (asystole, severe bradycardia) or pulseless electrical activity than in those presenting ventricular fibrillation ($P = 0.001$) (Table 3).

Table 4 details the relationship between mortality, CPR attempts characteristics, and postresuscitation status.

TABLE 4. Characteristics of Resuscitation and Mortality (Resuscitation Procedures, Duration of CPR, Postresuscitation Neurologic Status, and Complications in PICU)

	No. Patients	Initial Mortality (%)	Final Mortality (%)	Relative Risk of Final Mortality	95% CI	*P*
Time to initiation of CPR (minutes)						
<4	24	16.7	50	0.68	0.43–1.06	NS
4–10	12	50	66.6	1.02	0.65–1.6	NS
10–20	18	50	77.8	1.35	0.94–1.94	NS
>20	4	100	100	1.64	1.32–2.02	<0.05
Resuscitation procedures						
Intubation	73	58.9	83.5	2.51	1.36–4.62	<0.05
Peripheral venous access	50	46	74	1.05	0.82–1.35	NS
Central venous catheterization	11	45.5	90.9	1.30	1.03–1.64	<0.05
Intraosseous catheterization	28	78.6	96.4	1.55	1.27–1.89	<0.05
Adrenaline	62	62.9	88.7	2.18	1.42–3.35	<0.05
0 doses	32	31.3	75	0.12	0.09–0.14	<0.05
1 doses	5	20	60	0.31	0.15–0.64	<0.05
2 doses	7	42.9	57	0.29	0.15–0.54	<0.05
3 or more doses	39	71.8	97	1.43	1.16–1.75	<0.05
Bicarbonate	42	59.5	90	1.57	1.22–2.01	<0.05
0 doses	52	46.2	71	0.8	0.65–0.98	<0.05
1 doses	17	52.9	88	1.18	0.95–1.47	NS
2 or more doses	19	73.7	89	1.21	0.98–1.48	NS
Atropine	29	51.7	79	1.15	0.9–1.46	NS
Volume load	43	60.5	88	1.50	1.17–1.93	NS
Duration of CPR (minutes)						
<4	11	0	9	0.11	0.02–0.73	<0.05
5–9	2	0	50	0.69	0.17–2.76	NS
10–19	11	18.2	64	0.87	0.54–1.37	NS
20–29	14	50	71.4	0.97	0.68–1.38	NS
30–60	38	78.9	95	1.66	1.31–2.1	<0.05
>60	11	81.8	100	1.46	1.26–1.68	<0.05
Unknown	7	14.3	43	0.57	0.24–1.36	NS
Respiratory arrest at the arrival to the hospital	60	63.3	88.3	1.93	1.33–2.8	<0.05
Cardiac arrest at the arrival to the hospital	44	86.4	95.5	1.80	1.38–2.35	<0.05
Systolic blood pressure <70 mm Hg	33	78.9	95	3.20	1.78–5.74	<0.05
Blood gases						
pH <7.10	27	18.5	67	3.67	1.02–13.2	<0.05
PaO_2 <60 mm Hg	11	18.2	45.4	0.61	0.26–1.42	NS
SaO_2 <85%	11	9.1	64	1,32	0.73–2.39	NS
$PaCO_2$ >60 mm Hg	11	27.3	82	2.01	1.18–3.42	<0.05
CO_3H <15 mEq/L	20	20	70	2.10	1.03–4.28	<0.05
EB > −10	9	0	11	0.17	0.03–1.09	NS
Complications in the PICU	45					
Respiratory	17		53	1.35	0.71–2.56	NS
Shock	11		82	2.53	1.44–4.42	<0.05
Renal failure	8		75	1.98	1.12–3.52	<0.05
Nosocomial pneumonia	4		100	2.56	1.75–3.75	<0.05
Intracranial hypertension	12		33	0.69	0.29–1.64	NS
Cardiac insufficiency	10		90	2.68	1.68–4.87	<0.05

Initial mortality: nonsustained ROSC to CPR initial attempts.
Final mortality: mortality at 1 year.

CPR was initiated by emergency system staff (doctors and/or nurses) in 70.2% of cases, by paramedics in 13.8%, and by laypersons in 15.9%. Patients who were initially resuscitated by laypersons or paramedics had higher survival (53.6%) than those who were initially resuscitated by doctors and/or nurses (15.2%) ($P < 0.01$).

Time elapsed from the arrest episode to the onset of CPR was significantly longer for patients who finally died than for survivors ($P = 0.002$). Also, CRA mortality increased progressively in parallel with time (Table 4).

Sixty-two patients (65.2%) received adrenaline (5.7 ± 4.5 doses, range 1–20 doses). Forty-two (44.2%) were treated with bicarbonate (2.4 ± 2.3 doses), 29 (30.5%) received atropine (2 ± 1.9 doses), and 43 patients (34.7%) were treated with volume load (27.6 ± 25.9 mL/kg). In 19 patients (20%), at least 1 electric shock was delivered (4.5 ± 6.3 shocks). Survival was lower in children who required tracheal intubation (17.8% vs. 61.9%, $P < 0.001$), intraosseous access (3.6% vs. 37.9%, $P < 0.001$), adrenaline (epinephrine) administration (11.3% vs. 59.4%, $P < 0.0001$), bicarbonate administration (9.5% vs. 42.3% $P < 0.0001$), and volume expansion (11.6% vs. 41.2% , $P = 0.002$) (Table 4). Nonsurvivors received more doses of adrenaline than survivors (6.3 ± 4.5 vs. 1.8 ± 0.7) ($P = 0.001$). Volume load amount was higher in nonsurvivors (30 ± 27.4 mL/kg) than in survivors (14 ± 4.1 mL/kg) but the differences did not reach statistical significance ($P = 0.07$).

Initial and final survival was significantly lower in patients with longer CPR times ($P < 0.0001$) (Table 4, Fig. 2). Initial and final survival in patients with CPR time less than 20 minutes was 91.7% and 62.5%, respectively, which compares with 28.8% and 13.5% in patients who needed more than 20 minutes of CPR ($P < 0.0001$).

At the end of CPR attempts, the neurologic status of 45 children who initially survived was assessed: 8.8% were alert or responded to voice, 28.8% reacted to physical tactile stimulation, 22.2% did not respond but were pharmacologically sedated, and 40% were not reactive to painful stimulus without being sedated. Survival was 27.8% for patients who did not respond to stimulus, 50% for those sedated, 84.6% for those who responded to stimulus, and 100% for those who were alert or responded to voice at that time ($P < 0.0001$) (Table 4).

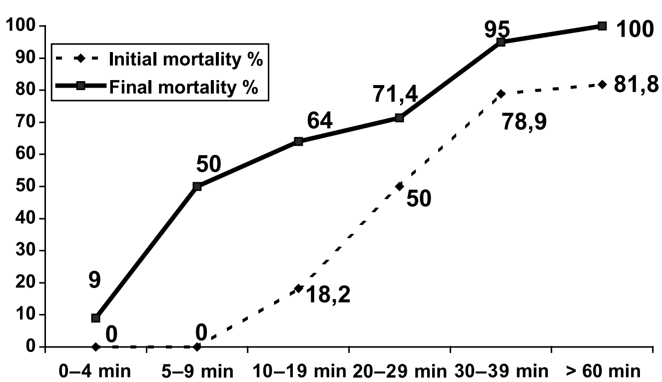

FIGURE 2. Relationship between the duration of cardiopulmonary resuscitation and mortality. (Initial mortality: nonsustained ROSC to CPR initial attempts. Final mortality: mortality at 1 year).

TABLE 5. Blood Gases and Survival

	Survivors	Nonsurvivors	*P*
pH	7.15 ± 0.18	6.91 ± 0.20	0.0001
Pa_{O_2} (mm Hg)	114.7 ± 111	88 ± 47.8	0.6
Hb saturation (%)	89.9 ± 8.6	78.3 ± 26.7	0.4
Pa_{CO_2} (mm Hg)	43.6 ± 14.5	56.9 ± 24.2	0.1
CO_3H (mEq/L)	16.5 ± 6.3	11.7 ± 4.4	0.03
Base excess	−11.1 ± 8.4	−17.6 ± 6.5	0.01

Seventy-eight patients were transported to the hospital, 47 by means of advanced life support ambulance (with physician and nurse), 24 by ambulance (with paramedics), 4 by helicopter (with physician and nurse), and 2 by private car (by laypersons). Survival of patients transported by car (0%), ambulance (25%), or helicopter (25%) was lower than survival of those transported by advanced life support ambulance (36.6%), but the differences did not reach statistical significance. Survival of patients with respiratory or cardiac arrest at the time of hospital arrival was lower than survival of the rest of the patients ($P < 0.001$) (Table 4). Children without venous access at hospital arrival had lower survival than children who had venous access at that time (18.2% vs. 39.6%) ($P = 0.01$). A blood gas analysis was conducted after CPR in 42 children; pH, bicarbonate, and base excess were significantly lower in nonsurvivors than in survivors (Table 5). A pH value lower than 7.10 and bicarbonate lower than 15 mEq/L were associated with lower survival (Table 4).

Also, patients who survived the initial CRA episode but suffered complications afterward had lower final survival than the rest of the children (Table 4).

The multivariate logistic regression analysis found that duration of resuscitation longer than 20 minutes was the variable that better predicted initial and final mortality (Table 6).

TABLE 6. Multivariate Logistic Regression Analysis

	Odds Ratio	95% CI	*P*
Initial Mortality			
Duration of CPR >20 minutes	27.133	5.662–130.020	<0.0001
The model correctly predicted the mortality of 77.6% of patients with a cutoff point of 0.5			
Final Mortality			
Duration of CPR >20 minutes	10.714	3.401–33.758	<0.0001
The model correctly predicted the mortality of 78.9% of patients with a cutoff point of 0.5			

TABLE 7. PCPC Scale at PICU Discharge, Hospital Discharge, and at 1 Year

Score	PCPC at PICU Discharge (27 Patients)	PCPC at Hospital Discharge (27 Patients)	PCPC at 1 Year (19 Patients)
1	20	21	16
2	2	1	—
3	0	1	1
4	1	1	—
5	4	3	2

One patient with score 5 at PICU discharge improved to score 3 at hospital discharge and maintained this score at 1 year.

One patient with score 5 and another with score 4 at hospital discharge died during the first year of follow-up.

One patient with score 2 and 5 patients with score 1 at hospital discharge were missing at 1-year evaluation.

Neurologic outcome scales were available for 27 patients at PICU and hospital discharge and for 19 children at 1-year follow-up. A high percentage of survivors had a normal or near-normal neurologic and functional status at both times (Tables 7 and 8).

DISCUSSION

To our knowledge, this is the first prospective and multicenter study of out-of-hospital pediatric CRA designed using the international Utstein guidelines for uniform data reporting that analyzes the prognostic factors. In our series, survival and long-term outcome was higher than in the majority of previously reported studies, both in adults[1–3] and in children.[4–6,11,16] This figure may be explained by the progressive improvement in health care and by the fact that in our country the out-of-hospital EMS vehicles include physicians and nurses. However, studies in adults[17] and children[10] found that the addition of advanced-life-support interventions did not improve the rate of survival after out-of-hospital cardiac arrest in a previously optimized emergency-medical-services system of rapid defibrillation. Another factor that may contribute to improve outcome could be the country-wide implementation of systematic pediatric basic and advanced-life-support courses from 1995.[18,19]

In our sample, significantly more boys suffered CRA than girls, as reported by others.[5,8] In adult series, men mortality has been higher than female mortality,[20] our results as well as other studies in children showed a similar mortality for both sexes.[4,5] Infants presented a higher mortality; like in other pediatric series, when CRA is secondary to sudden infant death syndrome, neurologic disease, or trauma, the prognosis becomes clearly worse.[6,12,16,21]

Studies in adults have demonstrated that CRA at home has a poor prognosis, probably in relation with a long time elapsed from the arrest to the start of basic life support and/or the arrival of the emergency system team.[22,23] However, we did not find survival differences when children arrested at home were compared with those arrested in other scenarios.

Out-of-hospital CRA patients had higher mortality than those arrested in-hospital,[3] possibly because the time elapsed from CRA to start of resuscitation was longer and also because in this scenario there were less opportunities for advanced life support and stabilization procedures. Our data support the idea that time from arrest to initiation of resuscitation is a key factor for survival of children after CRA.[23–27] Our results agree with adult's studies indicating that patients initially resuscitated by laypersons or paramedics had better survival.[25,28,29] This fact emphasizes the importance of early detection and treatment in CRA, a goal that could be achieved by means of life support teaching programs for citizens,[30] as well as with EMS that include staff specifically trained in pediatric life support. In adults, the effect of bystander CPR on survival has been related with: the interval between collapse and the start of bystander CPR; the quality of bystander CPR; the category of bystander; interval between collapse and the arrival of the ambulance; and the location of the arrest (effect more marked if the arrest took place outside the home).[29] Even more, one study found that survivors who received CPR by citizens achieved a better quality of life score at 1-year follow-up.[28]

Patients in respiratory arrest at the time of diagnosis have better initial and final survival than those in cardiac arrest.[12] Then, if the respiratory arrest episode can be immediately and adequately treated, the eventual development of cardiac arrest might be prevented and, subsequently, the outcome should be improved.

In our series, as in others studies in adults[2,25,26] and children[6] with out-of-hospital cardiac arrest, slow rhythms (detected at the first time the monitor is attached to the patient) were predictors of bad prognosis. We recorded ventricular fibrillation in 12% of CRA children, a percentage similar to other pediatric studies.[4,7,8] The availability of automated external defibrillator adapted to children and the new international guidelines on the use of automated external defibrillator in children should permit the pediatric

TABLE 8. POPC Scale at PICU Discharge, Hospital Discharge, and at 1 Year

Score	POPC at PICU Discharge (27 Patients)	POPC at Hospital Discharge (27 Patients)	POPC at 1 Year (19 Patients)
1	21	21	16
2	1	1	—
3	0	1	1
4	1	1	—
5	4	3	2

One patient with score 5 at PICU discharge improved to score 3 at hospital discharge and maintained this score at 1 year.

One patient with score 5 and another with score 4 at hospital discharge died during the first year follow-up.

One patient with score 2 and 5 patients with score 1 at hospital discharge were missing at 1-year evaluation.

population to obtain the benefits of the early defibrillation in case of arrest with shockable rhythms.[31]

Patients requiring more advanced-life-support procedures and more doses of epinephrine and bicarbonate had higher mortality, in accordance with other studies in children and adults.[2,6,12,32]

Despite several factors demonstrating an individual relationship with mortality, the logistic regression analysis showed that duration of CPR longer than 20 minutes was the best predictor of mortality, in agreement with other pediatric studies.[6,12]

The immediate neurologic assessment performed in our study, even simple, demonstrated some prognostic value. Children who responded to physical stimuli achieved better final survival than those who did not respond. Similar to other pediatric studies,[12] the clinical status at hospital arrival also demonstrated an influence on survival: pulseless patients, in respiratory arrest, without venous access, and with lower pH had higher mortality. This remarks the importance of medical treatment maintenance, not only at the scene, but also during transport.

Despite the high mortality observed in children who suffered out-of-hospital CRA, our results indicate that a significant percentage of survivors achieve normal or near-normal neurologic and functional status at 1-year follow-up. A recent retrospective pediatric study showed similar results[33] and the same has been reported in adults.[34]

Our study has 2 main limitations that must be considered. Only some out-of-hospital EMS and Pediatric Departments participated in the study and this could produce some bias on results. Also, the limited number of assessed patients and the small number of survivors make difficult to generalize the conclusions regarding neurologic outcome.

We conclude that out-of-hospital CRA in children still has a poor prognosis. Survival should be improved by means of better EMS, with specific knowledge and skills in pediatric resuscitation, as well as with strategies directed to increase the detection of children at risk by the general population and encouraging immediate basic life support by bystanders. Rescuers should be reinforced by the fact that in most of survivors normal neurologic status will be achieved. On the other hand, when resuscitation attempts need to be prolonged longer than 20 minutes, the survival possibilities are insignificant, and therefore, the stop of life support procedures should be considered.

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REFERENCES

1. Fredriksson M, Herlitz J, Nichol G. Variation in outcome in studies of out-of-hospital cardiac arrest: a review of studies conforming to the Utstein guidelines. *Am J Emerg Med*. 2003;21:276–281.
2. Engdahl J, Holmberg M, Karlson BW, et al. The epidemiology of out-of-hospital ''sudden'' cardiac arrest. *Resuscitation*. 2002;52:235–245.
3. Herlitz J, Bang A, Ekstrom L, et al. A comparison between patients suffering in-hospital and out-of-hospital cardiac arrest in terms of treatment and outcome. *J Intern Med*. 2000;248:53–60.
4. Engdhal J, Axelsson A, Bang A, et al. The epidemiology of cardiac arrest in children and young adults. *Resuscitation*. 2003;58:131–138.
5. Sirbaugh PE, Pepe PE, Shook JE, et al. A prospective, population-based study of the demographics, epidemiology, management and outcome of out-of-hospital pediatric cardiopulmonary arrest. *Ann Emerg Med*. 1999;33:174–184.
6. Young KD, Gausche-Hill M, McClung CD, et al. A prospective, population-based study of the epidemiology and outcome of out-of-hospital pediatric cardiopulmonary arrest. *Pediatrics*. 2004;114:157–164.
7. Mogayzel C, Quan L, Graves JR, et al. Out-of-hospital ventricular fibrillation in children and adolescents: causes and outcomes. *Ann Emerg Med*. 1995;25:484–491.
8. Hickey RW, Cohen DM, Strausbaugh S, et al. Pediatric patients requiring CPR in the prehospital setting. *Ann Emerg Med*. 1995;25:495–501.
9. Ronco R, King W, Donley DK, et al. Outcome and cost at a children's hospital following resuscitation for out-of-hospital cardiopulmonary arrest. *Arch Pediatr Adolesc Med*. 1995;149:210–214.
10. Pitetti R, Glustein JZ, Bhende MS. Prehospital care and outcome of pediatric out-of-hospital cardiac arrest. *Prehosp Emerg Care*. 2002;6:283–290.
11. Young KO, Seidel JS. Pediatric cardiopulmonary resuscitation: a collective review. *Ann Emerg Med*. 1999;33:195–205.

12. Schindler MB, Bohn D, Cox PN, et al. Outcome of out-of-hospital cardiac or respiratory arrest in children. *N Engl J Med*. 1996;335: 1473–1479.
13. Zaritsky A, Nadkarni V, Hazinski MF, et al. Recommended guidelines for uniform reporting of pediatric advanced life support: the pediatric Utstein style. *Resuscitation*. 1995;30:95–115.
14. y Grupo Español de Reanimación cardiopulmonar pediátrica y neonatal, López-Herce J, Domínguez P. Estudio epidemiológico sobre la parada cardiorrespiratoria en la infancia. *An Esp Pediatr*. 1998;48:332–333.
15. López-Herce J, García C, Domínguez P, et al. Characteristics and outcome of cardiorespiratory arrest in children. *Resuscitation*. 2004;63: 311–313.
16. Suominen P, Korpela R, Kuisma M, et al. Paediatric cardiac arrest and resuscitation provided by physician-staffed emergency care units. *Acta Anesthesiol Scand*. 1997;41:260–265.
17. Stiell IG, Wells GA, Field B, et al. Ontario Prehospital Advanced Life Support Study Group. Advanced cardiac life support in out-of-hospital cardiac arrest. *N Engl J Med*. 2004;351:647–656.
18. López-Herce J, Carrillo A, Sancho L, et al. Pediatric basic and advanced life support courses: first experience in Spain. *Resuscitation*. 1996;33: 43–48.
19. López-Herce J, Carrillo A, Rodríguez A, et al. Paediatric life support instructors courses in Spain. *Resuscitation*. 1999;41:205–209.
20. Wigginton JG, Pepe PE, Bedolla JP, et al. Sex-related differences in the presentation and outcome of out-of-hospital cardiopulmonary arrest: a multiyear, prospective, population-based study. *Crit Care Med*. 2002; 30(4 suppl):S131–S136.
21. Calkins CM, Bensard DD, Partrick DA, et al. A critical analysis of outcome for children sustaining cardiac arrest after blunt trauma. *J Pediatr Surg*. 2002;37:180–184.
22. Herlitz J, Eek M, Holmberg M, et al. Characteristics and outcome among patients having out of hospital cardiac arrest at home compared with elsewhere. *Heart*. 2002;88:579–582.
23. Herlitz J, Engdahl J, Svensson L, et al. Can we define patients with no chance of survival after out-of-hospital cardiac arrest? *Heart*. 2004;90: 1114–1118.
24. Herlitz J, Engdahl J, Svensson L, et al. A short delay from out of hospital cardiac arrest to call for ambulance increases survival. *Eur Heart J*. 2003;24:1750–1755.
25. Herlitz J, Bang A, Gunnarsson J, et al. Factors associated with survival to hospital discharge among patients hospitalised alive after out of hospital cardiac arrest: change in outcome over 20 years in the community of Göteborg, Sweden. *Heart*. 2003;89:25–30.
26. Haukoos JS, Lewis RJ, Niemann JT. Prediction rules for estimating neurologic outcome following out-of-hospital cardiac arrest. *Resuscitation*. 2004;63:145–155.
27. Lyon RM, Cobbe SM, Bradley JM, et al. Surviving out of hospital cardiac arrest at home: a postcode lottery? *Emerg Med J*. 2004;21: 619–624.
28. Stiell I, Nichol G, Wells G, et al. Health-related quality of life is better for cardiac arrest survivors who received citizen cardiopulmonary resuscitation. *Circulation*. 2003;108:1939–1944.
29. Holmberg M, Holmberg S, Herlitz J, et al. Factors modifying the effect of bystander cardiopulmonary resuscitation on survival in out-of-hospital cardiac arrest patients in Sweden. *Eur Heart J*. 2001;22: 511–519.
30. Pyles LA, Knapp J. Role of pediatricians in advocating life support training courses for parents and the public. *Pediatrics*. 2004;114: e761–e765.
31. Samson R, Berg R, Bingham R. PALS Task Force. Use of automated external defibrillators for children: an update. An advisory statement from the Pediatric Advanced Life Support Task Force, International Liaison Committee on Resuscitation. *Resuscitation*. 2003; 57:237–243.
32. Holmberg M, Holmberg S, Herlitz J. Low chance of survival among patients requiring adrenaline (epinephrine) or intubation after out-of-hospital cardiac arrest in Sweden. *Resuscitation*. 2002;54:37–45.
33. Horisberger T, Fischer JE, Fanconi S. One-year survival and neurological outcome after pediatric cardiopulmonary resuscitation. *Intensive Care Med*. 2002;28:365–368.
34. Fischer M, Fischer NJ, Schüttler J. One-year survival after out-of-hospital cardiac arrest in Bonn city: outcome report according to the ''Utstein style''. *Resuscitation*. 1997;33:233–243.

