



## Characteristics and outcome of cardiorespiratory arrest in children

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### Abstract

**Objective:** To analyse the present day characteristics and outcome of cardio-respiratory arrest in children in Spain. **Design:** An 18-month prospective, multicentre study analysing out-of-hospital and in-hospital cardio-respiratory arrest in children. **Patients and methods:** Two hundred and eighty-three children between 7 days and 17 years of age with cardio-respiratory 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). Three hundred and eleven cardio-respiratory arrest episodes, composed of 70 respiratory arrests and 241 cardiac arrests in 283 children were studied. Accidents were the most frequent cause of out-of-hospital arrest (40%), and cardiac disease was the leading cause (31%) of in-hospital arrest. Initial survival was 60.2% and 1 year survival was 33.2%. The final survival was higher in patients with respiratory arrest (70%) than in patients with cardiac arrest (21.1%) ( $P < 0.0001$ ). Although many individual factors correlated with mortality, multivariate logistic regression revealed that the best indicator of mortality was a duration of cardiopulmonary resuscitation of over 20 min (odds ratio: 10.35; 95% CI 4.59–23.32). **Conclusions:** In Spain, the present mortality from cardio-respiratory arrest in children remains high. Survival after respiratory arrest is significantly higher than after cardiac arrest. The duration of cardiopulmonary resuscitation attempt is the best indicator of mortality of cardio-respiratory arrest in children.

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**Keywords:** Children; Cardiac arrest; Respiratory arrest; Resuscitation; Cardiopulmonary resuscitation

### Resumo

**Objetivo:** Analisar as características actuais e o prognóstico da paragem cardio-respiratória nas crianças em Espanha. **Desenho:** Estudo prospectivo multicêntrico durante 18 meses para analisar as paragens cardio-respiratórias extra-hospitalares e intra-hospitalares nas crianças.

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**Doentes e Métodos:** Duzentas e oitenta e três crianças com idades compreendidas entre os 7 e os 17 anos vítimas de paragem cardio-respiratória. Os dados foram registados de acordo com o estilo Utstein. As variáveis de outcome foram a recuperação sustentada da circulação espontânea (sobrevivência inicial), e a sobrevivência ao fim de um ano (sobrevivência final). Foram estudados trezentos e onze episódios de paragem cardio-respiratória, compostos de 70 paragens respiratórias e 241 paragens cardíacas em 283 crianças. Os acidentes foram a causa mais frequente de paragem cardíaca extra-hospitalar (40%), e a doença cardíaca foi a principal causa (31%) de paragem intra-hospitalar. A sobrevivência inicial foi de 60.2% e a sobrevivência após um ano foi 33.2%. A sobrevivência final foi mais elevada nos doentes com paragem respiratória (70%) do que nos doentes com paragem cardíaca (21.1%) ( $p < 0.0001$ ). Embora muitos factores individuais se correlacionem com a mortalidade, uma análise de regressão logística multivariada revelou que o melhor indicador da mortalidade foi a duração da reanimação cardio-pulmonar superior a 20 minutos (odds ratio: 10.35; CI 4.59–23.32). **Conclusões:** Em Espanha, a mortalidade actual por paragem cardio-respiratória em crianças permanece elevada. A sobrevivência após paragem respiratória é significativamente mais elevada do que após paragem cardíaca. A duração das tentativas de reanimação cardio-pulmonar é o melhor indicador da mortalidade após paragem cardio-respiratória nas crianças.

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**Palavras chave:** Crianças; Paragem cardíaca; Paragem cardio-respiratoria; Reanimação cardio-pulmonar

## Resumen

**Objetivo:** Analizar las características y resultados actuales del paro cardiorrespiratorio en niños en España. **Diseño:** Estudio multicéntrico, prospectivo de 18 meses de duración, analizando el paro cardiorrespiratorio intra y extrahospitalario en niños. **Pacientes y métodos:** 283 niños entre 7 días y 17 años de edad con paro cardiorrespiratorio. Los datos fueron registrados de acuerdo con el estilo Utstein. Las variables de resultado fueron el retorno a circulación espontánea sostenida (sobrevivida inicial), sobrevivida a un año de plazo (sobrevivida final). Se estudiaron 311 episodios de paro cardiorrespiratorio, compuestos de 70 paros respiratorios y 241 paros cardíacos en 283 niños. Los accidentes fueron la causa mas frecuente de paro cardíaco extrahospitalario (40%), y la enfermedad cardiaca fue la causa principal (31%) de paro intrahospitalario. La sobrevivida inicial fue de 60.2% y a un año fue de 33.2%. La sobrevivida final fue mas alta en pacientes con paro respiratorio (70%) que en pacientes con paro cardíaco (21.1%) ( $P < 0.0001$ ). Aunque muchos factores individuales se correlacionan con la mortalidad, el análisis de regresión logística multivariable reveló que el mejor indicador de mortalidad fue la duración de la resucitación cardiopulmonar por encima de 20 minutos (odds ratio: 10.35; 95% CI 4.59–23.32). **Conclusiones:** En España, la mortalidad actual del paro cardiorrespiratorio en niños sigue alta. La sobrevivida después del paro respiratorio es significativamente más alta que después del paro cardiaco. La duración de las maniobras de reanimación cardiopulmonar es el mejor indicador de mortalidad del paro cardiorrespiratorio en niños.

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**Palabras clave:** Niños; Paro cardiaco; Paro respiratorio; Resucitación; Reanimación cardiopulmonar

## 1. Introduction

Despite the advances in prevention, training in cardiopulmonary resuscitation, and early treatment, mortality after cardio-respiratory arrest (CRA) remains very high both in adults [1–5] and children [6–9]. Until now, there are few prospective studies that analyse the causes, risk factors and outcomes of CRA in children [9]. Some studies showed that survival varies depending on the location of arrest, underlying disease, initial electrocardiographic (ECG) rhythm, the time elapsing between CRA and the initiation of resuscitation, and the duration of cardiopulmonary resuscitation (CPR) [6–18]. However, comparison of the different studies is complicated as many are retrospective, with a small number of patients, and different definitions of CRA, methods of description and analysis of the results have been used. The Utstein style provides uniform guidelines for reporting characteristics and outcome for in-hospital and out-of-hospital CRA in children [19,20]. To date, only one prospective study that analysed the outcome of in-hospital CRA in children in a single centre following the Utstein style guidelines has been reported [9].

The objective of the present study was to provide a prospective, multicentre, Utstein style report of paediatric out-of-hospital and in-hospital CRA to evaluate the factors associated with mortality, and to know the final outcome of survivors.

## 2. Patients and methods

An invitation to participate in the study was sent to all the paediatric intensive care units (PICU), paediatric departments and out-of-hospital emergency medical systems in Spain [21]. A protocol was drawn up in accordance with the Utstein style guidelines [19,20]. Patients aged from 7 days to 18 years were eligible for the study if they had presented in respiratory arrest (RA) defined as the absence of respiration requiring assisted ventilation, or cardiac arrest (CA) defined as the inability to palpate a central pulse, unresponsiveness, and apnoea or severe bradycardia of less than 60 bpm with poor perfusion in infants requiring external cardiac compressions and assisted ventilation [19,20]. Neonates admitted to neonatal intensive care units were excluded. The following

variables were recorded:

- 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, monitored variables, assisted ventilation an/or vasoactive drugs administered before the arrest, time elapsed from the arrest to starting of CPR, persons who performed the CPR life support manoeuvres 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 min; (b) return of spontaneous breathing; (c) CPR attributable complications; (d) neurological status at the end of the CPR; (e) later complications (in the PICU): respiratory (defined as a need for assisted ventilation for more than 48 h after the arrest due to respiratory causes), shock (defined as a systolic blood pressure 3 standard deviations below the normal value 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 mcg/kg/min or adrenaline (epinephrine) or noradrenaline (norepinephrine) >0.2 mcg/kg/min), renal failure (creatinine greater than twice 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 Centre for Disease Control), intracranial hypertension (intracranial pressure greater than 20 mmHg) and (f) cause and time of death.

The statistical study was performed using version 9 of the SPSS software statistical program. Pearson's Chi-squared test was used for qualitative variables analysis, and Fisher's exact test when  $n$  was less than 20 or when any value was less than 5. Student's  $t$ -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 (non-sustained ROSC), the mortality at hospital discharge, and final mortality (at 1 year). The  $P < 0.05$  value was considered significant. The data of the hospital discharge mortality and final mortality were very similar and therefore only the final mortality data are presented.

### 3. Results

We collected 311 episodes of cardiorespiratory arrest (CRA) that were either primarily cardiac or primarily respiratory in origin. These occurred from 1 April 1998 to 30 September 1999 in 283 children with a mean age of  $48 \pm 54.4$  months (range 7 days to 17 years) and mean weight of  $17.1 \pm 16$  kg (2.3–80 kg). Subsequent re-arrest (range 2–6) occurred

in the PICU in 17 patients. Characteristics of the patients and CRA, and the initial and final mortalities are summarised in Table 1 and Fig. 1.

#### 3.1. Mortality

A total of 189 patients (66.7%) died. One hundred and twelve patients (39.5%) did not sustain a return of spontaneous circulation after CPR initial attempts (initial mortality). Seventy-seven patients (27.2%) with an initially sustained ROSC died later (33 in the first 24 h after CRA, 23 between 1 and 7 days, 17 in hospital after 7 days and four after hospital discharge). The cause of mortality in these patients was brain death in 29 (15.3%), multi-organ failure in 32 (16.9%), non-response to CPR attempts after a new CRA in nine (4.7%), and decision to not attempt CPR in case of new CRA in seven (2.6%) (Fig. 1). Ten (34.4%) of the 29 patients with brain death became organ donors. Fourteen (82.3%) of the 17 children who suffered more than one episode of CRA died. The mortality of the children with more than one arrest was significantly higher than that of the patients with only one arrest episode (82.3% versus 59.7%) ( $P < 0.001$ ). No significant differences were found with regard to sex or weight between the patients who died and the survivors.

#### 3.2. Site of arrest

CRA occurred in a public place in 24.4% of the patients, at home in 9.1%, in a hospital emergency department in 17.6%, in a PICU in 41% and in other hospital areas in 7.7% of the patients. Initial mortality of out-of-hospital CRA was significantly higher than that of in-hospital CRA (44.8% versus 34.1%) ( $P = 0.04$ ). Final (1 year) mortality from out-of-hospital CRA, was also higher than that from in-hospital CRA (70.3% versus 63%), although the difference did not reach statistical significance. CRA at home or in a public place had an initial mortality higher than CRA in other environments ( $P = 0.016$ ). Although the final mortality was also higher, the difference did not reach statistical significance (Table 1).

#### 3.3. Type of arrest

At the time of recognition, 24.7% of the patients presented an RA and 75.3% a CA. Three of the further episodes were RA and 27 were CA. The initial and final mortalities from RA were significantly lower than that from CA ( $P < 0.001$ ) (Table 1; Fig. 1). The initial and final mortalities of the out-of-hospital CA (59.6% and 87.5%) were significantly higher than those of the in-hospital CA (37.6% and 71.5%) ( $P = 0.002$  and  $P = 0.004$ , respectively). The final mortality from CA occurring in the PICU (70.8%) was lower than those, which occurred in any of the other areas ( $P = 0.04$ ). Final mortality from RA was similar when compared the place of arrest.

Table 1  
Patients characteristics and mortality

	Number of patients	Initial mortality (%)	Final mortality (%)	Relative risk of final mortality	95% CI	P
<b>Age</b>						
<1 month	20	30	45	1		
1–12 months	85	50.6	71.8	1.59	0.96–2.64	0.022
1–8 years	119	37.8	63.8	1.38	0.83–2.29	0.147
>8 years	59	30.5	72.9	1.62	0.97–2.69	0.023
<b>Gender</b>						
Female	98	38.8	63.3	1		
Male	185	40	68.6	1.08	0.90–1.29	0.426
<b>Site of arrest</b>						
Home	26	57.7	73.1	1.46	0.91–2.36	0.09
Public place	69	50.7	73.9	1.45	0.93–2.26	0.051
Emergency department	50	30	64	1.28	0.8–2.04	0.26
PICU	116	36.2	65.5	1.29	0.83–2.01	0.19
Other hospital areas	22	22.7	50	1		
<b>In-hospital versus out-of-hospital</b>						
In-hospital	138	34.1	63	1		
Out-of-hospital	145	44.8	70.3	1.12	0.94–1.32	0.19
<b>Aetiology</b>						
Heart disease or arrhythmia	56	35.7	69.6	1		1
Respiratory disease	53	22.6	43.4	0.6	0.41–0.86	0.003
Neurological disease	50	36	66	0.95	0.73–1.23	0.68
Infectious disease	35	51.4	77.1	1.11	0.86–1.42	0.43
Drowning	24	37.5	54.2	0.78	0.52–1.17	0.18
SIDS	20	85	100	1.44	1.21–1.71	0.005
Trauma <sup>a</sup>	16	50	93.8	1.35	1.09–1.67	0.04
Metabolic disturbance	7	28.6	85.7	1.03	0.62–1.69	0.92
Foreign-body airway obstruction	5	0	20	0.29	0.05–1.67	0.04
Other	13	38.4	58.3	0.08	0.05–1.39	0.9
Unknown	4	75	100			
<b>Type of arrest</b>						
Respiratory	70	12.9	30	1		
Cardiac	213	48.4	78.9	3.31	2.45–4.47	<0.0001

SIDS: sudden infant death syndrome.

<sup>a</sup> Isolated head injury has been classified as neurological disease.

### 3.4. Aetiology of arrest

The underlying diseases were cardiac in 61 children (21.6%), neurological in 47 (16.6%), respiratory in 37 (13.1%), major congenital malformations in 33 (11.7%), oncological in 8 (2.8%), and other diseases in 39 (13.8%). Aetiology of arrest and mortality are presented in Table 1. The highest mortality was observed in sudden infant death syndrome and trauma patients, whereas the least mortality was recorded in respiratory diseases and foreign body airway obstruction ( $P < 0.0001$ ).

### 3.5. Previous treatment

One hundred and forty-two patients (50.2%) were being monitored at the moment of suffering their first episode of CRA, 87 patients (30.7%) were receiving mechanical ventilation, and 74 (26.1%) were being treated with vasoactive drugs

at the time of their first CRA. No mortality differences were found when monitored or ventilated patients were compared with the non-monitored or ventilated ones. However, patients receiving vasoactive drugs at the time of CRA had a mortality of 81.0%, significantly higher than that of those who were not being treated with such drugs (60.8%) ( $P = 0.002$ ).

### 3.6. ECG record

An ECG was recorded at the onset of the arrest in 236 patients. Slow rhythms were present in 74.6% of the cases of CRA, pulseless electrical activity in 7.6%, ventricular fibrillation (VF) or pulseless ventricular tachycardia (VT) in 10.2%, and sinus rhythm in 7.6%. There were no significant differences in the incidence of VF and pulseless VT between the in-hospital and out-of-hospital arrests. Initial mortality was higher in the patients who presented with slow rhythms (asystole, severe bradycardia or complete atrio-ventricular

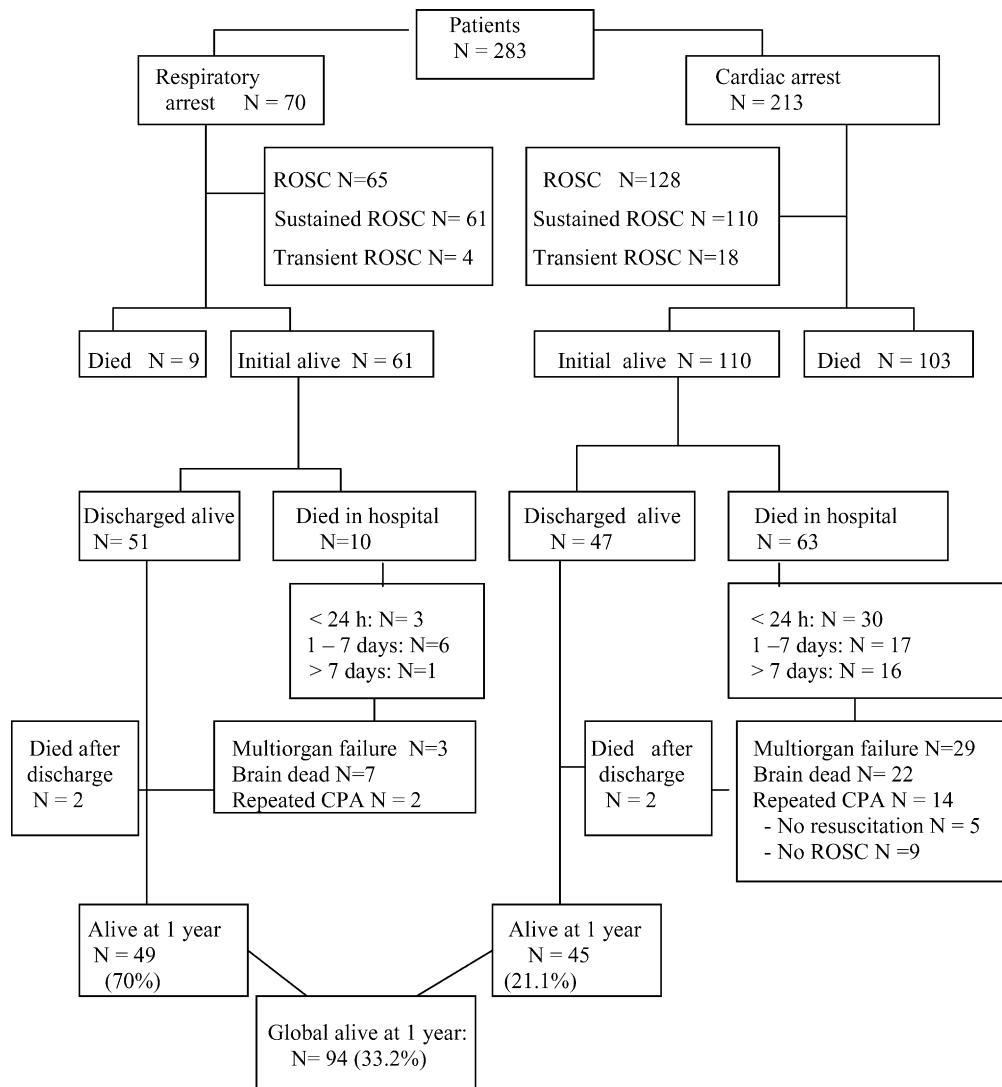


Fig. 1. Paediatric Utstein style template for recording outcome from respiratory and cardiopulmonary arrest.

block) than in those presenting with VF or pulseless VT ( $P = 0.001$ ). However, no significant differences were found in the final mortality (Table 2).

### 3.7. Characteristics of the resuscitation

Tables 2 and 3 detail the relationship between the initial and final mortality and the characteristics of the resuscitation attempts and the post-resuscitation status. CPR was initiated in 18.9% of the patients by the out-of-hospital emergency system using doctors and nurses, in 23.3% by hospital doctors and nurses, in 47.3% by PICU doctors and nurses, in 4.7% by paramedic staff and in 5.8% by laypersons. The period elapsed before the onset of CPR was significantly greater for the patients who died than for the survivors ( $P = 0.01$ ). CRA mortality increased progressively as the duration of the arrest before starting CPR increased (Fig. 2).

However, when CA and RA groups were analysed separately, this observation was only detected in CA patients ( $P = 0.04$ ). The initial (53.1%) and final (82.8%) mortality was higher in those patients, who did not receive basic life support (BLS) at the scene of the arrest than in those who did (initial mortality 35.6% and final mortality 61.2%) ( $P = 0.01$  and  $P = 0.001$ , respectively). Advanced CPR was performed in 205 patients (72.4%) at the arrest scene. Initial mortality was higher in those who did not receive advanced life support at the scene (51.3%) than in those who did 35.1% ( $P = 0.01$ ). The final mortality was also higher in patients who did not receive advanced CPR, 70.5% versus 65.3%, but the difference did not reach statistical significance. The initial and final mortality increased as the duration of the CPR increased ( $P < 0.0001$ ) (Fig. 3). These differences were maintained when the RA and CA were analysed separately ( $P < 0.0001$ ). Analysis of the relationship between mortal-

Table 2  
 Characteristics of resuscitation (time to initiation of CPR, previous treatment and initial cardiac rhythm)

	Number of patients	Initial mortality (%)	Final mortality (%)	Relative risk of final mortality	95% CI	P
Time to initiation of CPR						
<4 min	175	25.7	56.5	1		
4–10 min	18	33.3	61.1	1.1	0.75–1.63	0.64
10–20 min	21	52.4	81	1.46	1.14–1.87	0.02
>20 min	6	83.3	100	1.80	1.58–2.06	0.03
Previous treatment						
Monitored	142	33.8	66.2	0.98	0.83–1.15	0.90
Ventilation	87	40.2	72.4	1.12	0.95–1.33	0.21
Inotropic drugs	74	44.6	81.1	1.31	1.12–1.53	0.002
Cardiac rhythm						
Asystole/bradycardia/atrio-ventricular block	176	48.3	72.7	2.58	1.22–5.46	<0.001
Ventricular fibrillation/tachycardia	24	29.2	79.2	2.85	1.32–6.17	<0.001
Asystole	99	58.6	86.9	3.13	1.48–6.61	<0.001
Supraventricular bradycardia	62	27.4	51.6	1.74	0.79–3.83	0.12
Ventricular bradycardia	14	64.3	64.3	2.31	1.0–5.37	0.04
Pulseless electrical activity	18	38.9	83.3	3.0	1.38–6.50	<0.001
Ventricular fibrillation	19	26.3	73.7	2.65	1.20–5.86	0.005
Pulseless ventricular tachycardia	5	40	100	3.60	1.71–7.58	0.003
Complete atrio-ventricular block	1	100	100	3.60	1.71–7.58	0.13
Sinus rhythm	18	0	27.8	1		

Table 3  
 Characteristics of resuscitation and mortality (resuscitation manoeuvres, duration of CPR, post-resuscitation neurological status and complications in PICU)

	Number of patients	Initial mortality (%)	Final mortality (%)	Relative risk of mortality	95% CI	P
Resuscitation manoeuvres						
Intubation	236	41.1	72.5	2.82	1.64–4.85	<0.0001
Peripheral venous access	148	32.4	59.5	0.81	0.68–0.96	0.022
Central venous catheterization	115	36.5	78.3	1.37	1.16–1.62	<0.0001
Intraosseous catheterization	40	70	97.5	1.61	1.43–1.81	<0.0001
Adrenaline	170	50.5	83.7	2.82	2.04–3.89	<0.0001
0 dose	91	11.3	29.6	1		
1 dose	24	8.3	50	1.65	1.05–2.14	0.03
2 doses	34	17.6	67.6	1.93	1.62–2.31	0.001
3 or more doses	112	67.8	94.6	6.69	2.44–19.31	<0.0001
Bicarbonate	128	48.9	86.1	1.88	1.55–2.29	<0.0001
0 dose	138	26.8	45.6	1		
1 dose	48	35.4	77	1.74	1.37–2.22	<0.001
2 or more doses	80	58.7	90	2.04	1.67–2.49	<0.001
Atropine	69	47.8	72.5	1.14	0.95–1.36	0.19
Volume load	96	54.2	84.4	1.51	1.29–1.76	<0.0001
Duration of CPR						
<4 min	61	1.4	19.7	1		
5–9 min	22	3.3	36.4	1.85	0.87–3.91	0.11
10–19 min	47	7.8	68	3.35	1.94–5.79	<0.001
20–29 min	26	40.7	80.7	3.91	2.26–6.67	<0.001
30–60 min	83	77	92.8	4.72	2.83–7.86	<0.001
>60 min	25	77.8	100	5.08	3.06–8.44	<0.001
Post-resuscitation neurological status						
No response to stimulation	118	–	56.8%	1.96	1.55–2.48	<0.0001
Complications in the PICU						
Respiratory	77	–	67.5%	1.55	1.19–2.02	0.001
Shock	64	–	85.9%	2.35	1.83–3.02	<0.001
Renal failure	42	–	90.5%	2.14	1.73–2.65	<0.0001
Nosocomial pneumonia	46	–	63%	1.26	.95–1.66	0.13
Intracranial hypertension	24	–	91.7%	1.93	1.58–2.37	<0.0001
Cardiac insufficiency	49	–	77.6%	1.73	1.36–2.20	<0.0001

Initial mortality: non-sustained ROSC to CPR initial attempts. Final mortality: mortality at one year.

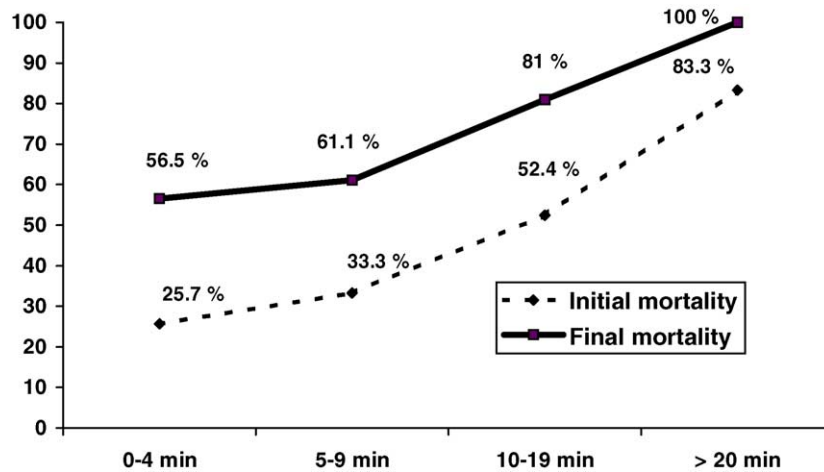


Fig. 2. Relationship between the time elapsed before the starting of CPR and the initial and final mortality. Initial mortality: non-sustained ROSC to CPR initial attempts. Final mortality: mortality at 1 year.

ity and each one of the life support procedures performed revealed that the initial and final mortalities were higher in children who required tracheal intubation, intraosseous access, adrenaline (epinephrine) or bicarbonate administration, and volume expansion than in the remainder of the patients (Table 3). The children who died received more doses of adrenaline ( $5.3 \pm 4$  versus  $1.8 \pm 0.8$ ),  $P < 0.0001$ , of bicarbonate ( $2.5 \pm 1.8$  versus  $1.7 \pm 1.2$ ),  $P = 0.002$ , and of atropine ( $2.0 \pm 1.6$  versus  $1.1 \pm 0.3$ ),  $P = 0.002$ , than the survivors.

### 3.8. Status after resuscitation

In the neurological assessment at the end of CPR, 8.2% of the patients were alert or responded to voice, 10.6% reacted to physical tactile stimulation, 34% did not respond but were pharmacologically sedated, and 48.6% who were

not sedated did not react to pain. The mortality in those patients who did not respond to stimuli (56.8%) was significantly higher than that of the remainder of the patients (18.7%),  $P < 0.0001$  (Table 3). Patients who survived after the initial CRA episode but suffered later complications in the PICU had a higher final mortality than the rest of children (Table 3).

### 3.9. Predictive factors of mortality

The multivariate logistic regression analysis found that the only factor, which predicted initial and final mortality in both RA and CA, was a duration of CPR longer than 20 min. For the initial mortality after CRA, only one other factor, the presence of CA at presentation, increased the prognostic power of the duration of CPR (Table 4).

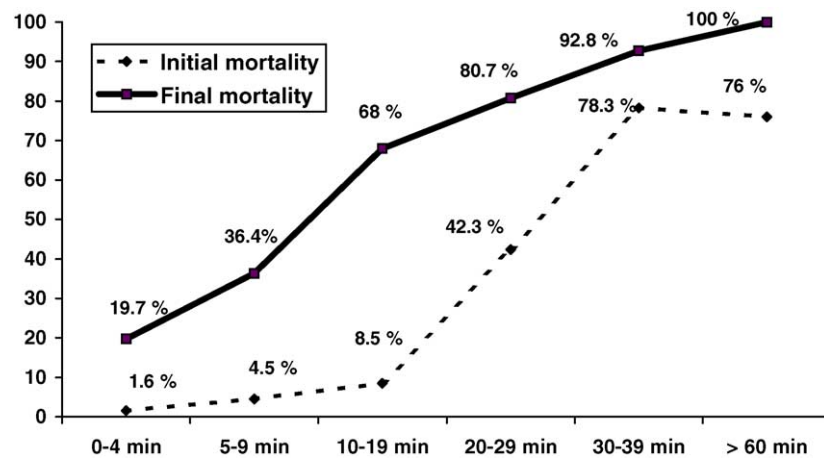


Fig. 3. Relationship between the duration of cardiopulmonary resuscitation and the initial and final mortality. Initial mortality: non-sustained ROSC to CPR initial attempts. Final mortality: mortality at 1 year.

Table 4  
Multivariate logistic regression analysis

	Odds ratio	CI 95%	P value	Predictive capacity <sup>a</sup> (%)
Cardiac arrest (initial mortality)	36.1701	12.9495–101.0285	0.0000	82.28
Cardiac arrest (final mortality)	16.9886	6.7226–42.9317	0.0000	77.94
Respiratory arrest (initial mortality)			NS	
Respiratory arrest (final mortality)	6.6767	1.7210–25.8242	0.006	77.94
Cardiorespiratory arrest (initial mortality)	40.8478	14.8362–112.4640	0.0000	83.89
Cardiac arrest <sup>b</sup>	6.3546	1.6086–25.1030	0.0083	85.31
Cardiorespiratory arrest (final mortality)	10.356	4.5983–23.3244	0.0000	74.88

Length of cardiopulmonary resuscitation more than 20 min. Initial mortality: non-sustained ROSC to CPR initial attempts. Final mortality: mortality at one year.

<sup>a</sup> Percentage of patients in which the model correctly predicted the mortality or survival.

<sup>b</sup> Cardiac arrest plus duration of CPR of over 20 min.

#### 4. Discussion

To our knowledge, this is the first prospective, multicentre study that used the Utstein style to report the aetiology and characteristics of out-of-hospital and in-hospital cardiac and respiratory arrest in children, and that analyses the factors relating to prognosis. There is only one previous study, performed in a single hospital, which has analysed in-hospital cardio-respiratory arrest following the Utstein style [9]. Although ours is not an epidemiological study, a large number of patients were included from a wide range of centres in many regions of Spain, from out-of-hospital emergency services in rural areas to PICU in third level big city hospitals; this permitted us to study a representative sample of CRA in children in our country.

Survival from paediatric CRA arrest has been dismal in most studies in the past. It is encouraging that in the present study, crude long-term survival (at 1 year) was 33% (21.1% in CA and 70% in RA). This is a figure that is slightly higher than in previous series [6,8–10,13,22], particularly taking into account that both in-hospital and out-of-hospital arrest have been included. This result may be explained by the progressive improvement in health care and by the fact that in our country, the out-of-hospital emergency medical system vehicles include physicians and nurses. Another factor that may contribute to improved outcome is the countrywide implementation of systematic paediatric advanced life-support courses from 1995 [23]. On the other hand, although participation in the study was open, we cannot rule out bias related to the recruitment of patients from centres with experienced paediatric life-support staff and consequently with better results.

##### 4.1. Characteristics of patients and aetiology

In our study, significantly more boys suffered CRA than girls, as reported by others [6,7,9], although the mortality rate was similar in both sexes [6,10]. No relationship was found between age and mortality due to CRA, although the patients under 1 month of age had a slightly higher survival, a finding not reported in other studies in children [10,11]. As in other

series, children with CRA secondary to sudden infant death syndrome and trauma had the highest mortality [11,13,24].

##### 4.2. Site of arrest

Out-of-hospital CA patients had higher initial and final mortality than in-hospital CA patients. The survival of children after out-of-hospital CRA was lower, possibly because the time elapsed from CRA and the start of resuscitation was longer and also because in this environment, there were less opportunities for advanced life-support and stabilisation procedures [17]. Our data support the idea that the time from the arrest to the initiation of resuscitation, the staff skills and available material resources to initiate resuscitation, are main factors for the survival of children after CRA [5,13,25]. When CRA is diagnosed by the out-of-hospital emergency services, the possibilities for survival were similar to those of an in-hospital CRA. This fact could also be explained by the brief period of time elapsed from the collapse to the arrival to the hospital in such cases.

As expected, our results confirm the prognostic importance of the duration of CRA before CPR. When this figure was unreliable, or a long period before CPR can be assumed and this could explain why in our series, those patients with unknown duration of CRA had the worst outcome. Both initial and final mortalities were higher in the patients in whom basic life support was not started at the scene [4,25]. This fact emphasises the importance of early diagnosis and treatment in CRA, a goal that must be achieved by means of life-support training for citizens as well as with emergency medical systems staff specifically trained in paediatric life support [26].

##### 4.3. Type of arrest

The patients in respiratory arrest at the time of diagnosis have better initial and final survival than those in cardiac arrest [1,6,8,27,28]. In children, most CRA in children have respiratory, trauma or neurological causes. These children usually develop respiratory arrest which if not treated soon leads to cardiac arrest. On the other hand, if the respiratory arrest episode is treated adequately immediately, the eventual

development of cardiac arrest can be prevented and subsequently, the outcome should be improved.

#### 4.4. Electrocardiographic record

Ten percent of CRA children presented with shockable rhythms (VF and pulseless VT), a percentage similar to other paediatric studies [6,10,13,23] and significantly lower than the values reported in adult patients [1–5,25]. In our series, slow rhythms (the monitor is attached to patient) were predictors of an initial bad prognosis. However, in contrast to that reported in adults [1–5,25,29] and in other paediatric studies [15], we have found no significant differences in the final mortality between the slow rhythms and shockable rhythms, a finding was also reported in other paediatric studies [10,23]. A significant percentage of VF cases in adults are cardiac in origin and, if an adequate shock is delivered, ROSC can be achieved in most cases. However, VF in children is frequently secondary to other causes with a poorer prognosis (trauma, hypoxia, hyperkalaemia) [15] and this could explain, in part, these differences. Besides this, until mid 2003, automated external defibrillators (AED) were only recommended for adults, and children were deprived of this therapeutic resource. We hope that from now on, the availability of AED adapted to children and the new international guidelines on the use of AED in children should permit the paediatric population to obtain the benefits of the early defibrillation in case of arrest with a shockable rhythm [30].

#### 4.5. Predictive factors of mortality

As expected, the patients requiring more advanced life-support procedures and more doses of adrenaline and bicarbonate had a higher mortality [7,8,17,31]. However, the total resuscitation time interval was the best predictor of mortality and survival, both in RA and CA. It is remarkable that a life-support time period of more than 20 min predicted a final mortality of 78%. These data fit with other paediatric studies [6,8–11,13,15,17,32] and could be helpful in deciding when to stop life-support procedures in arrested children. ROSC was not achieved in 40% of the children suffering CRA, and 19% of patients who survived initially died in the next 24 h. The most frequent causes of late death were brain death and multiorgan failure. Also, as other studies have noted, patients who have more than one CRA episode have a higher mortality [10,11].

We conclude that nowadays, CRA in children continues to have a high mortality. Most of the deaths occur in cardiac arrest cases with an unknown or long period from arrest to initial resuscitation efforts. On the other hand, when children are found in respiratory arrest and resuscitation is started soon, the survival rate is encouraging. In most of cases, death occurs in the first 24 h after the first episode of CPA. The duration of cardiopulmonary resuscitation is the best indicator of mortality in CRA in children.

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