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Long-term evolution after in-hospital cardiac arrest in children: Prospective multicenter multinational study☆

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ABSTRACT

Objective: The main objective was to study survival and neurologic evolution of children who suffered in-hospital pediatric cardiac arrest (CA). The secondary objective was to analyze the influence of risk factors on the long term outcome after CA.
Methods: prospective, international, observational, multicentric study in 48 hospitals of 12 countries. CA in children between 1 month and 18 years were analyzed using the Utstein template. Survival and neurological state measured by Pediatric Cerebral Performance Category (PCPC) scale one year after hospital discharge was evaluated.
Results: 502 patients with in-hospital CA were evaluated. 197 of them (39.2%) survived to hospital discharge. PCPC at hospital discharge was available in 156 of survivors (79.2%). 76.9% had good neurologic state (PCPC 1–2) and 23.1% poor PCPC values (3–6). One year after cardiac arrest we could obtain data from 144 patients (28.6%). PCPC was available in 116 patients. 88 (75.9%) had a good neurologic evaluation and 28 (24.1%) a poor one. A neurological deterioration evaluated by PCPC scale was observed in 40 patients (7.9%). One year after cardiac arrest PCPC scores compared to hospital discharge had worsen in 7 patients (6%), remained constant in 103 patients (88.8%) and had improved in 6 patients (5.2%).

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Conclusion: Survival one year after cardiac arrest in children after in-hospital cardiac arrest is high. Neurologic outcome of these children a year after cardiac arrest is mostly the same as after hospital discharge. The factors associated with a worst long-term neurological outcome are the etiology of arrest being a traumatic or neurologic illness, and the persistency of higher lactic acid values 24 h after ROSC. A standardised basic protocol even practicable for lower developed countries would be a first step for the new multicenter studies.

Introduction

Despite efforts to improve outcome after pediatric in-hospital cardiac arrest (IHCA), survival rates are still low. Most patients achieve return of spontaneous circulation (ROSC), reflecting that post-resuscitation care is a major issue in outcome.[1–13] High mortality has mainly been attributed to the post-resuscitation syndrome, which involves hypoxia-ischemia and reperfusion, and its potential damage to the brain.[13–21] Neurological injury has been related to an important decrease in survival rates after IHCA in both children and adults. However, there are no multicenter, multinational prospective studies on CA in children that have analyzed long-term neurological follow-up. In previous studies performed on the same prospective register we have analyzed the pre-arrest and resuscitation factors,[11] the ventilation and oxygenation factors[13] and post-resuscitation factors associated with mortality.[20] The main objective of the present study was to analyze survival and neurologic evolution of children who suffered in-hospital pediatric cardiac arrest (CA). The secondary objective was to analyze the factors affecting long-term neurological outcome of in-hospital CA in children.

Methods

An open multicenter prospective study was designed and information and an invitation to participate were sent to the pediatric departments and PICUs of hospitals in Latin-American countries, Spain, Portugal, and Italy.

The study was approved by local Institutional Review Boards. Registration on the website[22] was necessary to participate in the study. A protocol was drawn up in accordance with the Utstein style.[23,24] Children aged from 1 month to 18 years who suffered in-hospital CA between December 2007 and December 2009 were included. CA was defined by the presence of all the following signs: unresponsiveness, apnea, absence of signs of life and absence of a palpable central pulse or bradycardia with less than 60 beats per minute (bpm) with poor perfusion in infants requiring external cardiac compressions and assisted ventilation.

All data were entered via a secure, encrypted website and were electronically submitted to the coordinating center. That center performed a review of all records to ensure data quality, and site investigators were queried to complete missing data and resolve discrepancies.

Patient-related variables and arrest and life support related parameters have been previously published[11,25] as for the relationship between ventilation and oxygenation and other post-ROSC parameters with mortality.[13,20]

Hospital course and clinical and neurological status at pediatric intensive care unit (PICU) discharge, hospital discharge and one year after CA, according to the pediatric cerebral performance category (PCPC) were registered.[26] Variable definitions were based on Utstein-style guidelines.[23,24] The primary endpoint was survival with to hospital discharge. The secondary outcome measure was neurological status at hospital discharge and one year after CA; a good neurological status was defined as a PCPC score of 1 or 2 on hospital discharge or 1 year follow-up or discharge PCPC no worse than on admission.[26,27]

Statistical analyses were conducted using SPSS software version 18.1 (SPSS Inc, Chicago, IL, USA). Outcomes were compared between groups using the chi-square (χ^2) test or Fisher's exact test for categorical variables. Univariate and multivariate logistic regression analysis was performed to assess the influence of each one of the factors on neurological outcome at the different periods.

Results

Twelve countries participated, and data was obtained from forty-eight hospitals. The analysis included 563 episodes of in-hospital CA in 502 patients. CA occurred in the PICU in 50% of cases, in the emergency department in 26.8%, and in other hospital areas in 23.2%. Return of spontaneous circulation (ROSC) for more than 20 min was achieved in 349 patients (69.5%), but 152 (30.3%) patients died later in hospital due to new CA (32.9%), multiple organ dysfunction (27%), limitation of medical therapy (25%) or brain death (15.1%): 197 patients (39.2%) survived to hospital discharge.

Five patients were rescued with extracorporeal membrane oxygenation (ECMO) during CPR and four of them survived to hospital discharge. The characteristics of the 502 patients, pre-arrest factors, and cardiac arrest and resuscitation factors associated with mortality have been previously published.[11]

Out of the 197 patients who survived to hospital discharge, 156 (79.2%) had at least one neurological evaluation registered. At one year follow-up, survival was achieved by 144 patients (28.6% of the 502 patients) and cerebral performance scales were registered in 116 patients (80.5% of survivors) (Fig. 1). In a previous study we included the evaluation of 117 patients,[11] but for the present work we reviewed again the evolution of all patients. In one patient we considered that the data obtained by the investigator was not sufficient to assure properly the neurologic evaluation.

76.9% of the survivors were found to have a good neurological outcome at hospital discharge. One year after CA, PCPC scores compared to hospital discharge had worsen in 7 patients (6%), remained constant in 103 patients (88.8%), and had improved in 6 patients (5.2%).

Only 40 (7.9%) patients were found to have worsened their PCPC scale values in comparison with their pre-arrest situation. In 24 of these patients neurological exploration and additional diagnostic tests could be registered (Table 1). An electroencephalogram was performed only in 20 of survivors during their PICU stay. In 4 patients a normal continuous EEG register was observed, global slowing was diagnosed in another 9, electric patterns of cortical irritation were registered in 4 patients, low voltage activity with no evidence of electric crisis was seen in 2 patients, and one patient presented a burst suppression EEG.

Radiological findings were obtained in 11 of these patients. In 8 patients an MRI was performed, 2 underwent a CT scan and 1 a transfontanellar ecography. The most frequent finding were a right cerebral medial artery stoke (2 patients) and the affection of basal ganglia (2 patients) (Table 1).