Characterizing cardiac arrest in children undergoing cardiac surgery: A single-center study

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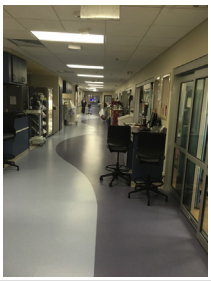
ABSTRACT

Objectives: To characterize cardiac arrest in children undergoing cardiac surgery using single-center data from the Society of Thoracic Surgeons and Pediatric Advanced Life Support Utstein-Style Guidelines.

Methods: Patients aged 18 years or less having a cardiac arrest for 1 minute or more during the same hospital stay as heart operation qualified for inclusion (2002-2014). Patients having a cardiac arrest both before or after heart operation were included. Heart operations were classified on the basis of the first cardiovascular operation of each hospital admission (the index operation). The primary outcome was survival to hospital discharge.

Results: A total of 3437 children undergoing at least 1 heart operation were included. Overall rate of cardiac arrest among these patients was 4.5% (n = 154) with survival to hospital discharge of 84 patients (66.6%). Presurgery cardiac arrest was noted among 28 patients, with survival of 21 patients (75%). Among the 126 patients with postsurgery cardiac arrest, survival was noted among 84 patients (66.6%). Regardless of surgical case complexity, the median days between heart operation and cardiac arrest, duration of cardiac arrest, and survival after cardiac arrest were similar. The independent risk factors associated with improved chances of survival included shorter duration of cardiac arrest (odds ratio, 1.12; 95% confidence interval, 1.05-1.20; $P = .01$) and use of defibrillator (odds ratio, 4.51; 95% confidence interval, 1.08-18.87; $P = .03$).

Conclusions: This single-center study demonstrates that characterizing cardiac arrest in children undergoing cardiac surgery using definitions from 2 societies helps to increase data granularity and understand the relationship between cardiac arrest and heart operation in a better way. (J Thorac Cardiovasc Surg 2016;■:1-9)



Cardiac ICU at Arkansas Children's Hospital.

Central Message

Characterizing cardiac arrest using definitions from 2 societies helps to understand the relationship between cardiac arrest and heart operation.

Perspective

The major strength of our single-center study is the use of the Society of Thoracic Surgeons' definitions to characterize heart operations and the use of Pediatric Advanced Life Support Utstein-Style Guidelines to characterize cardiac arrest. Using definitions from 2 societies helps increase data granularity and understand the relationship between cardiac arrest and heart operation in a better way.

CONG

Cardiac arrest is not rare in pediatric patients, occurring in 2% to 6% of children admitted to a pediatric intensive care unit (ICU).[1-3] Children who undergo cardiac surgery are at greater risk of experiencing a cardiac arrest, with cardiac arrest occurring in 6% of infants in the postoperative period compared with less than 2% incidence of cardiac arrest in pediatric ICUs.[4-7] It has further been demonstrated that children with surgical-cardiac disease have significantly better survival to hospital discharge after an in-hospital cardiac arrest compared with children with medical-cardiac disease and noncardiac disease.[7]

Previous studies evaluating cardiac arrest in children undergoing cardiac surgery are limited by data on cardiac diagnoses, heart operations, definition of cardiac arrest, outcomes after cardiac arrest using Utstein-Style Guidelines (eg, return of spontaneous circulation, 24-hour survival, survival at hospital discharge, good neurologic outcomes), and temporal relationship between heart operation and cardiac arrest.[7-10] A comprehensive study

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Abbreviations and Acronyms

AHA = American Heart Association
CPB = cardiopulmonary bypass
CPR = cardiopulmonary resuscitation
ECMO = extracorporeal membrane oxygenation
ECPR = extracorporeal cardiopulmonary resuscitation
GWTG-R = Get With the Guidelines–Resuscitation
ICU = intensive care unit
STS-EACTS = Society of Thoracic Surgeons–European Association for Cardiothoracic Surgery

evaluating this relationship using standardized definitions is missing from the current literature.

We sought to address these knowledge gaps by designing this single-center study to characterize cardiac arrest in children undergoing cardiac surgery using the Society of Thoracic Surgeons and Pediatric Advanced Life Support Utstein-Style Guidelines. The aim of this study was to evaluate the incidence of cardiac arrest and Utstein's outcomes after cardiac arrest in children undergoing heart operations of varying complexity.

MATERIALS AND METHODS

Study Population

Patients aged 18 years or less having a cardiac arrest for 1 minute or more during the same hospital stay as the heart operation during the period from January 2002 to December 2014 at the Arkansas Children's Hospital qualified for inclusion. Patients having a cardiac arrest both before or after heart operation were included. Heart operations (with or without cardiopulmonary bypass [CPB]) were classified on the basis of the first cardiovascular operation of each hospital admission (the index operation). For patients with multiple qualifying arrests, only the initial arrest event was included. Patients receiving only drugs or positive pressure ventilation without chest compressions or defibrillation were excluded (Figure 1). Patients receiving chest compressions for less than 1 minute were excluded. Patients with no documented index operation, patients associated with surgical closure of an isolated patent ductus arteriosus only, and patients weighing 2.5 kg or less undergoing isolated patent ductus arteriosus ligation were excluded. Patients associated with operations that were not classified into 1 of the Society of Thoracic Surgeons–European Association for Cardiothoracic Surgery (STS-EACTS) Mortality Categories (category 1, lowest mortality risk; category 5, highest mortality risk) (21 patients) were excluded.[11] The Institutional Review Board at the University of Arkansas for Medical Sciences approved review of patient medical records, and the need for informed consent was waived.

Data Collection and Outcome Variables

The data collected from hospital database included demographic data, preexisting conditions, operation details, prearrest characteristics, arrest characteristics, and outcome data. We developed the hospital database on Utstein-style template, which allowed us to standardize and review the resuscitation data.[12] The primary outcome was survival to hospital discharge. Secondary outcome measures included return of spontaneous circulation for more than 20 minutes, 24-hour survival, and neurologic status at discharge. Neurologic status was assessed at the time of discharge using the Pediatric Cerebral Performance Category scale, which divides outcome into the following 6 categories: (1) normal, age-appropriate neurodevelopment function; (2) mild disability; (3) moderate disability; (4) severe disability; (5) coma or vegetative state; and (6) brain death. Good neurologic status was defined as a score of 1, 2, 3, or no change in score from prearrest to hospital discharge.[13,14]

Definitions

Cardiac arrest was defined as any event characterized by pulselessness or critically compromised perfusion treated with external chest compressions for 1 minute or more or defibrillation that elicited a unit-wide or hospital-wide emergency response. This definition is in consensus with the American Heart Association (AHA) operational definition for a cardiopulmonary resuscitation (CPR) event.[15,16] CPR was defined as therapies aimed at preserving the integrity of vital organs during cardiopulmonary arrest by restoring spontaneous circulation.[15,16] Extracorporeal CPR (ECPR) was defined as the use of extracorporeal membrane oxygenation (ECMO) as a resuscitation therapy in children refractory to conventional CPR.[15,16] The use of ECPR in our institution follows AHA recommendations, thereby limiting the use of ECPR to in-hospital cardiac arrest that is refractory to initial resuscitation efforts when the cause of arrest is reversible or the patient could be a candidate for heart transplantation. A rapid deployment ECMO system exists at the Arkansas Children's Hospital that is jointly managed by the cardiovascular surgery and cardiovascular intensive care team. A preassembled and primed ECMO circuit with the surgical and medical personnel needed for initiation of mechanical support is available at all times in the hospital.

First documented rhythm was defined as the first electrocardiographic rhythm recorded at the time the patient required chest compressions. Arrest event duration was defined as the time from beginning of chest compressions or defibrillation to return of spontaneous circulation or cessation of resuscitation efforts. The primary procedure of each index operation performed was classified by STS-EACTS Mortality Category. Patients were grouped into 2 levels of complexity on the basis of the STS-EACTS Mortality Categories (categories 1, 2, and 3 are classified as "low" complexity, and categories 4 and 5 are classified as "high" complexity).[11] The other study definitions are elaborated in study Table 1.

Statistical Analysis

Descriptive statistics were performed using standard summary statistics, such as frequency and percentages or median and quartiles as appropriate. Patient demographics, preexisting conditions, operation characteristics, interventions before cardiac arrest, and arrest characteristics were compared between survivors and nonsurvivors using the Fisher exact test and Wilcoxon rank-sum test as appropriate. We also summarized important cardiac arrest characteristics after stratifying patients by 1 of the 5 surgical risk categories and by 8 benchmark operations. We used multivariate logistic regression models to determine the risk factors associated with survival to hospital discharge among patients with cardiac arrest. For multivariable models, the following patient, operation characteristics, and arrest variables were prospectively selected for inclusion in multivariable models a priori because of their established clinical importance and on the basis of existing literature: age, year of cardiac arrest, complexity of operation performed, arrest before cardiac surgery, recurrent arrest, use of CPB for heart operation, time of arrest (nights/weekends), arrest duration, drugs used during arrest (number of epinephrine doses, use of alkanizing agents, use of calcium), use of defibrillator, and ECPR.[7-10]

We further used a backward stepwise regression method for variable selection method to better elucidate predictors associated with survival to hospital discharge. At each stage, variables with P values less than .2