Survival status and functional outcome of children who required prolonged intensive care after cardiac surgery

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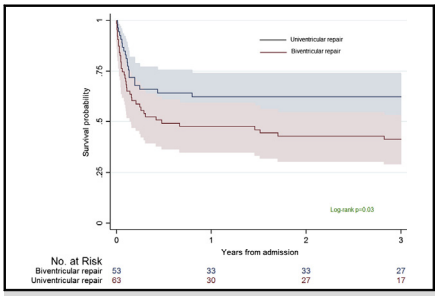
ABSTRACT

Background: Children who require prolonged intensive care after cardiac surgery are at risk of high mortality. The long-term survival and functional outcome of these children have not been studied in detail.

Methods: Children who stayed in intensive care for >28 days after cardiac surgery from 1997 to 2012 were studied in a single institution. A total of 116 patients were identified; 107 (92%) were <1 year of age and 63 (54%) had univentricular physiology.

Results: The incidence of children requiring prolonged intensive care increased from 1.01/100 undergoing cardiac surgery in 1997 to 2000 to 2.66/100 in 2009 to 2012 (P trend = .002). This increase coincided with an increase in the number of children with hypoplastic left heart syndrome having prolonged intensive care during the same period (0.13/100 in 1997-2000 to 1.0/100 in 2009-2012; P trend = .001). Survival to pediatric intensive care unit (PICU) discharge was 74% (95% confidence interval [CI], 65-82) and 51% (95% CI, 41-59) at 3 years. Factors associated with mortality were univentricular repair (hazard ratio [HR], 2.12; 95% CI, 1.21-3.70; P = .008) and acute renal failure (HR, 3.01; 95% CI, 1.77-5.12; P < .001), but era did not influence mortality (1997-2005 vs 2006-2012; log-rank P = .66). Among PICU survivors, 3-year survival in those who did not need early reoperation was 81% (95% CI, 66-90), compared with 58% (95% CI, 42-71) in those who required early reoperation (log-rank P = .01). Among survivors, 36% had either moderate or severe disability and 13% had poor quality of life.

Conclusions: The incidence of children requiring prolonged intensive care after cardiac surgery has increased in our institution. Our data suggest that the long-term outcome for most of these children is poor, especially after univentricular repair. (J Thorac Cardiovasc Surg 2016;152:1104-12)



Kaplan-Meier survival analysis for biventricular and univentricular group.

Central Message

The incidence of children requiring prolonged intensive care after cardiac surgery has increased, and outcomes in this group are poor.

Perspective

Overall mortality after pediatric cardiac surgery is low and declining. However, outcomes among children who required prolonged intensive care after cardiac surgery are poor and have not improved in recent decades. More knowledge about these children will help us establish research priorities and formulate guidelines involving various aspects of the care process with the goal to improve outcomes.

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Overall mortality after pediatric cardiac surgery is low and declining,[1-3] and this progress has been achieved despite an increase in case complexity.[4] However, in certain high-risk groups, such as children who have required prolonged intensive care after cardiac surgery, there is very limited information on long-term survival and functional outcome. The limited literature in this area reports risk factors for prolonged intensive care after surgery and only reports early survival.[5-8] An understanding of long-term outcomes in this complex group is particularly important in the current era of low postoperative mortality.

Scanning this QR code will take you to the supplemental tables for this article.

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Abbreviations and Acronyms

CPB = cardiopulmonary bypass
ECMO = extracorporeal membrane oxygenation
HLHS = hypoplastic left heart syndrome
HR = hazard ratio
HSUV = health state utility value
IQR = interquartile range
LOS = length of stay
MGOS = modified Glasgow outcome score
PICU = pediatric intensive care unit

A recent review of pediatric intensive care units (PICUs) across Australia and New Zealand showed that children with a primary cardiac diagnosis account for the majority of those requiring prolonged intensive care, and that this proportion has increased in recent years.[9] There are likely to be several factors contributing to this increase, including increasing numbers of children with complex circulations undergoing surgery[4,10] and the widespread use of extracorporeal membrane oxygenation (ECMO) during cardiopulmonary resuscitation in children with cardiac disease.[11,12]

Evaluation of long-term outcomes in these children is fundamental in evaluating the effectiveness of care beyond simple measurement of mortality. Knowledge of factors associated with poor long-term outcome might assist in care planning for this difficult group. Information on outcomes could also be valuable to health care staff counseling families during prolonged and complicated postoperative PICU stays. In this study, we review our experience over a 16-year period with infants and children who required prolonged intensive care (defined as >28 days in intensive care) after cardiac surgery.

More specifically, the aims of this review are (1) to analyze trends in admission rates of children who needed prolonged PICU stay after cardiac surgery between 1 January 1997 and 31 December 2012, (2) to identify risk factors for short- and long-term mortality, and (3) to report long-term survival patterns, functional outcome, and quality of life among survivors.

MATERIALS AND METHODS

All infants and children admitted to intensive care at the Royal Children's Hospital, Melbourne, after cardiac surgery between 1 January 1997 and 31 December 2012 (16 years) with a PICU length of stay (LOS) >28 days are included. Eligible patients were identified from the PICU database and all information was collected from this resource and from medical records. Information concerning the total number of children undergoing cardiac surgery and total number of cardiac surgeries during each year of study was obtained from the perfusion department database. Children with medical cardiac disease (cardiomyopathy, myocarditis, etc.) and those admitted to PICU following commencement of long-term ventricular assist device support were excluded.

The PICU at the Royal Children's Hospital is a 22-bed multidisciplinary unit. All major cardiac surgeries are performed here for infants and children from 4 Australian states (Victoria, Tasmania, South Australia, Northern Territory) covering a population of around 8 million. Cardiac surgeries for all major congenital heart lesions, including heart transplantation, are performed at this center. The Human Research and Ethics Committee at the Royal Children's Hospital approved the study.

Data Collection

The following variables were collected. Demographic variables included age at admission, weight, gestation at birth, preoperative intubation, presence of comorbid condition, noncardiac congenital abnormalities and genetic defects, PICU and hospital LOS, duration of mechanical ventilation, cardiopulmonary bypass (CPB), and cross clamp time. Clinical variables included open sternum after surgery, major airways disease (malacia, stenosis, or external compression), pulmonary hypertension, arrhythmia, chylothorax, diaphragm palsy, necrotizing enterocolitis,[13] renal failure,[14] nosocomial bacteremia, cardiac arrest, requirement for ECMO, and need for early reoperation. Study variables and definitions are shown in Table E1.

Long-term functional outcome and quality of life among survivors was assessed at least 6 months after discharge using the modified Glasgow outcome score (MGOS). The MGOS is a global assessment tool of independent living and social integration. A standardized questionnaire (Table E2) for the MGOS is used by research assistants trained in outcome evaluation during outcome calls. The functional outcome obtained by the MGOS divides children into the following categories: normal, functionally normal (physically and intellectually normal) but requiring medication or medical supervision; mild disability but likely to lead an independent existence; moderate disability and dependent on care; severe disability and totally dependent on care (including persistent vegetative state); and death. Quality of life was assessed using the Health Utilities Index Mark 1.[15] Four attributes in the Health Utilities Index Mark 1 were defined as follows: (1) mobility/physical activity; (2) self-care/role activity; (3) social/emotional function; and (4) health problems. The different levels within each category were assigned a numerical value, and an overall health state utility value (HSUV) was calculated. The HSUV for all possible health states lies between 1.00 and −0.21, where 1.00 is healthy, 0.00 is dead, and negative values reflect a state "worse than dead." Four outcome categories were assigned: good (HSUV, 1-0.7); moderate (HSUV, 0.69-0.3); poor (HSUV, 0.29-0); and very poor (HSUV, <0). Children <2 years of age at the time of follow-up were not assigned an HSUV score. The questionnaire used for assessment of functional status is shown in Table E2.

Statistics

Continuous variables are presented as medians with interquartile range (IQR) and categorical variables as number (%). Continuous variables were compared using the Mann-Whitney rank-sum test, and categorical variables were compared using the χ^2 test. If a patient had more than one prolonged admission after cardiac surgery, only the first admission was used in the analysis. Significance of trends in the number of children needing prolonged intensive care admission was assessed using Poisson regression. Children were categorized according to the year of admission, and the incidence rate ratios used for assessing the trend were calculated for each 4-year period of study.

Comparisons were made for 2 groups of children: the entire cohort of children who required prolonged admission after cardiac surgery, and the cohort of children who survived the prolonged PICU admission. The outcome of interest was 3-year survival and a multivariable Cox proportional-hazards model was used for the 2 groups of children to identify risk factors associated with mortality. For group 1 (the entire cohort), survival was evaluated from day 29 of PICU admission, with day 1 defined as the day after day 28, to 3 years. For group 2 (the cohort who survived PICU prolonged admission), survival was evaluated from date of PICU discharge to 3 years. Data were censored on the date of death. Children who were alive were censored from the analysis on the date when

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