Outcomes of extracorporeal cardiopulmonary resuscitation for refractory cardiac arrest in adult cardiac surgery patients

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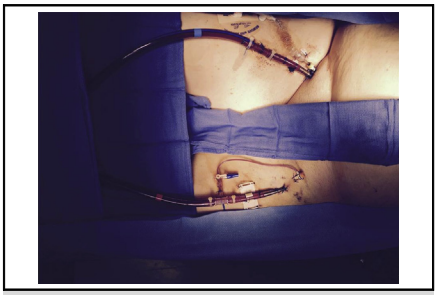
ABSTRACT

Background: The role of extracorporeal cardiopulmonary resuscitation (ECPR) in adult cardiac surgery patients with refractory cardiac arrest is uncertain. We hypothesized that ECPR would be associated with better than expected outcomes in this group of patients.

Methods: We conducted a single-center retrospective cohort study of adult cardiac surgery patients who underwent ECPR for refractory cardiac arrest during a 6-year period (2010 to 2015). In-hospital mortality, survival at last follow-up, and cerebral performance category (CPC) were examined as outcomes, and potential risk factors for mortality were explored.

Results: Twenty-three patients underwent ECPR when spontaneous circulation did not return with conventional resuscitation. Thirty-day mortality was 65.2%, and in-hospital mortality was 69.6%. Six of the 23 patients (26.1%) were discharged with a favorable neurologic outcome, defined as CPC 1 or 2. Most patients who died had multiple organ dysfunction syndrome (43.8%), and a smaller number had severe brain injury (25.0%). Kaplan-Meier survival analysis suggested age as a critical factor affecting survival ($P = .04$, log-rank test).

Conclusions: ECPR may have a role in younger adult cardiac surgery patients who experience refractory cardiac arrest. Future studies are needed to identify patients who will benefit most from ECPR. (J Thorac Cardiovasc Surg 2016;152:1133-9)



Peripheral venoarterial extracorporeal life support cannulation with a venous cannula in the right femoral vein and an arterial cannula in the left common femoral artery. The distal perfusion cannula, a 6 F sheath, is in the left superficial femoral artery.

Central Message

ECPR may have a role in younger adult cardiac surgery patients experiencing refractory cardiac arrest.

Perspective

The role of ECPR in refractory cardiac arrest after adult cardiac surgery is uncertain. Our study results suggest that ECPR may provide better than expected outcomes, particularly in young patients.

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MCS

Adult in-hospital cardiac arrest remains a significant problem, with more than 200,000 arrests per year.[1] The majority of these arrests (80%) begin as pulseless electrical activity (PEA) or asystole; the remainder, as ventricular arrhythmias. Historically, the mortality rate for in-hospital cardiac arrests has been between 80% and 90%.[2] Approximately one-third of survivors have a clinically significant neurologic disability at discharge. Fortunately, the last decade has seen modest improvements in mortality rates and neurologic outcomes,[2] likely due to advances in both the resuscitation process itself and postarrest management.

After cardiac surgery, patients are uniquely susceptible to cardiac arrest, which affects up to 5% of patients.[3] This increased vulnerability arises from the nature of

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Abbreviations and Acronyms

ACLS = advanced cardiac life support
AHA = American Heart Association
CCPR = conventional cardiopulmonary resuscitation
CPC = cerebral performance category
ECLS = extracorporeal life support
ECPR = extracorporeal cardiopulmonary resuscitation
ICU = intensive care unit
OR = operating room
PEA = pulseless electrical activity
ROSC = return of spontaneous circulation

the procedures performed. After cardiac surgery, the myocardium is more irritable and likely to suffer a lethal arrhythmia related to ischemia during the procedure, reperfusion injury, air embolism, or cardiac tamponade. How centers respond to cardiac arrest after surgery is as variable as the success rate of resuscitation.[3] The European Association of Cardiothoracic Surgery has adopted a standardized resuscitation algorithm for cardiac surgery patients. This algorithm is similar to the American Heart Association (AHA) advanced cardiac life support (ACLS) algorithms, but includes early sternal reentry and lower bolus doses of vasoactive medications.[4,5]

The use of extracorporeal life support (ECLS) has increased dramatically in recent years, and recent case series and cohort studies suggest that pediatric patients with refractory cardiac arrest may benefit from extracorporeal cardiopulmonary resuscitation (ECPR).[6,7] In adults, the role for ECPR is less clear and neither European guidelines or AHA guidelines recommend ECPR as part of standard resuscitation. The 2015 update to the AHA's ACLS guidelines notes that there is insufficient evidence to recommend the routine use of ECPR for patients with cardiac arrest, but that ECPR may be considered in selected patients for whom the cause is potentially reversible.[8]

The purpose of the present study was to review our institution's experience with ECPR in cardiac surgery patients who experience refractory cardiac arrest after surgery, a patient population with particularly poor survival. We hypothesized that ECPR would be associated with better than expected outcomes in patients with refractory cardiac arrest.

METHODS

Subjects

The University of Maryland's Institutional Review Board approved this study. We performed a retrospective cohort study of all adult patients who received ECPR for refractory cardiac arrest after cardiac surgery during a 6-year period (2010 to 2015). Patients who had ECPR were identified using our institution's ECLS database. Only patients who had cardiac surgery with cardiopulmonary bypass or transcatheter aortic valve replacement were included. We confirmed that we had captured all cases by reviewing all postsurgical arrests that occurred during the study period in our institutional Society of Thoracic Surgeons database. Refractory arrest was defined as a cardiac arrest in which standard resuscitation did not achieve a return of spontaneous circulation (ROSC) and it was determined that the patient would not survive without ECPR. Our general practice is to initiate the ECPR process if ROSC is not achieved within 10 minutes. For all patients, we recorded the following variables: age, sex, history of diabetes mellitus, history of hypertension, baseline creatinine, preoperative left ventricular ejection fraction, preoperative right ventricular function, type of surgery, cardiopulmonary bypass time during the index operation, postoperative day of the arrest, putative cause of arrest, initial heart rhythm during the arrest, minutes of conventional cardiopulmonary resuscitation (CCPR) before institution of ECPR, and cannulation scheme.

ECLS and Resuscitation Details

Our center has a well-established ECLS program, and more than 300 patients received ECLS for various indications during the study period. The typical ECLS circuit at our center includes a Rotaflow centrifugal pump (Maquet, Fairfield, NJ) and Quadrox oxygenator (Maquet). Heparin is used for anticoagulation, with a target activated partial thromboplastin time of 60 to 80 seconds or an activated clotting time of 180 to 200 seconds in patients receiving venoarterial ECLS.

Cardiac surgeons performed all cannulations during the study period. The decision of central or peripheral cannulation was made by the attending surgeon depending on which procedure was deemed the most expedient. Before initiation of ECLS, resuscitation was performed according to modified ACLS guidelines that included the European Association of Cardiothoracic Surgery's recommendation for early sternal reentry in patients at <10 days postsurgery. Post-ECPR care was provided by a multidisciplinary team that included intensivists, cardiac surgeons, nurses, perfusionists, and respiratory therapists. ECLS flows were targeted to achieve a cardiac index of $\geq$2.2 L/min/m^2. All patients were supported with a low- to moderate-dose inotropic agent (typically epinephrine) to promote left ventricular ejection and prevent cardiac thrombus formation. Mean arterial pressure was targeted at 65 to 80 mm Hg.

Transthoracic echocardiography was performed approximately every 2 to 3 days during ECLS to confirm left ventricular decompression and evaluate cardiac recovery. Three patients had an intra-aortic balloon placed for augmented left ventricular unloading. No patient underwent mechanical left ventricular venting, atrial septostomy, or placement of an Impella circulatory assist device (Abiomed, Danvers, Mass), because these are not standard practices in patients receiving ECPR at our center. ECLS weaning trials were attempted every 2 to 3 days. Ventricular function was assessed by echocardiography, and cardiac output was measured by thermodilution with a pulmonary artery catheter. Patients who maintained a cardiac index of >2.0 L/min/m^2 and a mean arterial pressure of $\geq$65 mm Hg on a single inotropic agent with minimal ECLS support ($\leq$2 L/min) were considered ready for a formal weaning trial in the operating room (OR).

Temperature Management

There was no formal protocol for temperature management in ECPR recipients during the study period. In 17 patients, temperature was maintained at 36°C for the first 24 hours after arrest and then kept below 38°C for the remainder of ECLS. Six patients were cooled to 32°C to 34°C during the first 24 hours after arrest and then maintained below 38°C for the remainder of ECLS.