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Clinical Paper

Resuscitative extracorporeal membrane oxygenation for in hospital cardiac arrest: A Canadian observational experience

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ABSTRACT

Background: Among patients with reversible conditions who sustain cardiac arrest, extracorporeal membrane oxygenation (ECMO) may support end organ perfusion while bridging to definitive therapy.
Methods: A single center retrospective review (February 2008–September 2013) of adults receiving ECMO for cardiac arrest ≥15 min duration refractory to conventional management (E-CPR) or profound cardiogenic shock following IHCA (E-CS) was conducted. The primary outcome was 30-day survival with good neurologic function defined as a cerebral performance category (CPC) of 1–2. Secondary outcomes included intensive care unit (ICU) and hospital length of say, duration of mechanical ventilation, and univariate predictors of 30-day survival with favorable neurologic function.
Results: Thirty-two patients (55 ± 11 years, 66% male) were included of which 22 (69%) received E-CPR and 10 (31%) received E-CS following return of spontaneous circulation (ROSC). Cardiac arrest duration was 48.8 ± 21 min for those receiving E-CPR and 25 ± 23 min for the E-CS group. Patients received ECMO support for 70.7 ± 47.6 h. Death on ECMO support occurred in 7 (21.9%) patients, while 7 (21.9%) were bridged to another form of mechanical circulatory support, and 18 (56.3%) were successfully decannulated. ICU length of stay was 7.5 [3.3–14] days and ICU survival occurred in 16 (50%) of patients. 30-Day survival was 5 (50%) in the E-CS group, 10 (45.4%) in the E-CPR group, and 15 (47%) overall. All survivors had CPC 1–2 neurologic status.
Conclusion: In this single center experience, the use of resuscitative ECMO was associated with neurologically favorable 30-day survival in 47% of patients with prolonged IHCA (H2012:172).

1. Introduction

Outcomes of in-hospital cardiac arrest (IHCA) have changed modestly in recent decades despite modern approaches to cardiopulmonary resuscitation (CPR).[1–3] Estimates of survival to hospital discharge remain unfavorable, varying from 7 to 18% among adults with IHCA.[4,5] Resuscitative extracorporeal membrane oxygenation (ECMO) was first applied to IHCA in 1976 among a population of patients with pulmonary emboli and cardiothoracic trauma,[6] but early attempts had high rates of complications. Technological advances including low resistance, rapidly primed centrifugal pumps and heparin-coated circuits have since reduced bleeding complications,[7] and ultrasound has increased the safety of

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percutaneous access.[8] The portability of ECMO units has improved dramatically, allowing broader use in diverse hospital settings and the pre-hospital environment.[9,10]

Recently ECMO has gained popularity in the resuscitation of patients with severe cardiopulmonary compromise. When applied to select patients with reversible conditions who sustain cardiac arrest (E-CPR)[11] or develop profound cardiogenic shock (E-CS),[12] ECMO may support end organ perfusion while bridging to definitive therapy. Reports of survival following E-CPR for IHCA range from 28 to 42% in retrospective series,[13–17] to 40% in a 135 patient meta-analysis.[18] Despite these encouraging reports, two recent trials of E-CPR with propensity matched control groups reached conflicting conclusions regarding therapeutic benefit.[19,20] Younger age[18] and shorter low – flow duration[16,18,21] have been associated with greater likelihood of survival, however knowledge of other predictors of outcome among recipients of resuscitative ECMO is evolving.

Although international consensus recommendations cite growing evidence for resuscitative ECMO at capable centers,[22] requirements for specialized equipment and timely access to rapid response ECMO teams have limited its broad application. Outside of Eurasia, resuscitative ECMO for adult IHCA has been performed at limited sites in North America,[23,24] but has not yet been reported in Canada. We sought to determine 30-day mortality and neurologic outcome among a broad population of non-cardiotomy patients receiving ECMO following IHCA at a tertiary care Canadian center. Second, we examined univariate predictors of 30-day survival.

2. Methods

2.1. Study design

We performed a retrospective cohort study examining the clinical records of consecutive adult patients who received veno-arterial ECMO following witnessed IHCA at a single academic tertiary-care center (St. Boniface Hospital, Winnipeg, Canada) between February 2008 and September 2013. Informed consent was waived for this retrospective chart review. The study protocol received approval from the University of Manitoba and St. Boniface Hospital research ethics review boards.

2.2. Data collection

A list of variables including demographics, comorbidities, ECMO-related variables, laboratory data, and in-hospital clinical course was generated during interdisciplinary focus group meetings based on results of published ECMO literature and consensus of biologic plausibility. Thereafter, pre-specified variables were obtained from the medical record. Patients were categorized as E-CPR if ECMO cannulation occurred during ongoing cardiopulmonary resuscitation and as E-CS if ECMO was initiated for refractory cardiogenic shock following return of spontaneous circulation (ROSC) post-cardiac arrest. Low flow time was defined as the total duration of cardiopulmonary resuscitation that occurred prior to ECMO cannulation. Patients who received ECMO for profound hypothermia or drug overdose were excluded from this analysis. The primary outcome was 30-day survival with good neurologic function defined as a cerebral performance category (CPC) of 1–2.[25] CPC status was ascertained by review of the medical record. Data abstractors were not blinded to patient management details. Secondary outcomes included intensive care unit (ICU) and hospital length of say, duration of mechanical ventilation, and univariate predictors of 30-day survival with favorable neurologic function.

2.3. Patient selection

Candidates for resuscitative ECMO (E-CPR or E-CS) were evaluated by the mechanical circulatory support surgeon on call. Inclusion criteria for E-CPR were (i) witnessed cardiac arrest ≥15 min with immediate CPR, (ii) an identifiable, reversible cause, and (iii) no apparent contraindication to aggressive medical care such as an advanced directive. Inclusion criteria for E-CS were refractory cardiogenic shock following IHCA defined by hypotension (systolic blood pressure < 90 mmHg) and insufficient systemic oxygen delivery despite inotropic/vasopressor support and/or intra-aortic balloon counterpulsation. Insufficient systemic oxygen delivery was defined as clinical or biochemical evidence of tissue hypoxia as evidenced by progressive metabolic acidosis, urine output <0.5 cc/kg/h, or central venous oxygen saturation <70%.

Relative exclusion criteria for resuscitative ECMO included septic shock, uncontrolled infection, active traumatic hemorrhage, multi-system organ failure, advanced malignancy, heparin induced thrombocytopenia, peripheral arterial disease with lower extremity ischemia, morbid obesity (body mass index > 40), and aortic dissection.

2.4. ECMO conduct

ECMO cannulation was established with 15-19F arterial and 24/29-30/33 two-stage venous cannulas using a percutaneous approach whenever possible. The ECMO circuit was comprised of a femoral venous line connected to a BioMedicus 540 centrifugal pump (Medtronic, Minneapolis, MN, USA) that propelled blood through a Medtronic Affinity NT oxygenator/heat exchanger into the common femoral arterial cannula. Circuits were primed with 600 mL of room temperature lactated ringers solution. Following ECMO initiation, unresponsive patients (Glasgow Coma Score ≤ 8) received therapeutic hypothermia with temperature targets of 33–34 °C for 24 h. An infusion of intravenous heparin was maintained to achieve a target activated clotting time of 160–200 s. The etiology of cardiac arrest was confirmed using coronary angiography, echocardiography, and computed tomography where applicable. Aggressive therapeutic intervention was undertaken to correct the underlying pathology including percutaneous coronary intervention, catheter ablation, coronary artery bypass grafting and valve repair or replacement.

After 24 h of support patients were considered for initiation of the weaning protocol if signs of end-organ recovery were evident on moderate pulmonary and inotropic support. This was accomplished by gradually reducing ECMO flow while observing for signs of myocardial recovery via echocardiography and clinical assessment of adequacy of systemic oxygen delivery. If weaning was unsuccessful after 7–10 days of support but end-organ function was improving and transplant candidacy was confirmed, the patient was transitioned to a long-term ventricular assist device. However, if weaning was unsuccessful and the patient was not deemed to be a transplant candidate, life-sustaining care was withdrawn following multidisciplinary discussion with the patient's family and treatment team.

2.5. Statistical analysis

Normally distributed continuous variables were reported as mean ± standard deviation (SD) and compared using Student's *t*-test. Non-normally distributed variables were reported as median and interquartile range (IQR) and compared using the Mann–Whitney U test. Categorical variables were expressed as frequencies and were compared using the chi-squared or Fisher's exact test. Univariate predictors of 30-day survival with good neurologic function (CPC 1–2) were determined. Variables with a p