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# Veno-arterial extracorporeal membrane oxygenation (VA-ECMO) for emergency cardiac support☆,☆☆

Sun Terri, MD [a,*], Guy Andrew, MD [b], Sidhu Amandeep, MSc [c], Finlayson Gordon, MD [a,f], Grunau Brian, MD MHSc [d], Ding Lillian, MSc [e], Harle Saida, BSc [e], Dewar Leith, MD [g], Cook Richard, MD, MSc [g], Kanji Hussein D., MD, MSc MPH [b,f]

[a] Department of Anesthesiology, Pharmacology and Therapeutics, Faculty of Medicine, University of British Columbia, Vancouver General Hospital, Rm 330, 910 W 10th Ave, V5Z 1M9 Vancouver, British Columbia, Canada
[b] Faculty of Medicine, University of British Columbia, 317-2194 Health Sciences Mall, V6T 1Z3 Vancouver, British Columbia, Canada
[c] Perfusion Services, Vancouver General Hospital, 910 W 10th Ave, V5Z 1M9 Vancouver, British Columbia, Canada
[d] Department of Emergency Medicine, University of British Columbia, Rm 3300, 910 W 10th Ave, V5Z 1M9 Vancouver, British Columbia, Canada
[e] Cardiac Services BC, Provincial Health Services Authority, 700-1380 Burrard Street, V6Z 2H3 Vancouver, British Columbia, Canada
[f] Department of Medicine, Division of Critical Care, Faculty of Medicine, University of British Columbia, Critical Care, Vancouver General Hospital, 2438-855 West 12th Avenue, V5Z 1M9 Vancouver, British Columbia, Canada
[g] Cardiovascular Surgery, Faculty of Medicine, University of British Columbia, Cardiac Surgery, Vancouver General Hospital, 950 West 10th Avenue, V5Z 1M9 Vancouver, British Columbia, Canada

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ABSTRACT

*Purpose:* Veno-arterial extracorporeal membrane oxygenation (VA-ECMO) may provide benefit to patients in refractory cardiac arrest and cardiogenic shock. We aim to summarize our center's 6-year experience with resuscitative VA-ECMO.
*Materials and methods:* A retrospective medical record review (April 2009 to 2015) was performed on consecutive non-cardiotomy patients who were managed with VA-ECMO due to refractory in- or out-of-hospital cardiac (IHCA/OHCA) arrest (E-CPR) or refractory cardiogenic shock (E-CS) with or without preceding cardiac arrest. Our primary outcome was survival to hospital discharge and good neurological status (Cerebral Performance Category 1–2).
*Results:* There were a total of 22 patients who met inclusion criteria of whom 9 received E-CPR (8 IHCA, 1 OHCA) and 13 received E-CS. The median age for E-CPR patients was 52 [IQR 45, 58] years, and 54 [IQR 38, 64] years for E-CS patients. Cardiac arrest duration was 70.33 (SD 39.56) min for the E-CPR patients, and 24.67 (SD 26.73) min for the 9 patients treated with E-CS who had previously arrested. Initial cardiac arrest rhythms were pulseless electrical activity (39%), ventricular fibrillation (33%), or ventricular tachycardia (28%). A total of 18/22 patients were successfully weaned from VA-ECMO (78%); 16 patients survived to hospital discharge (73%) with 15 in good neurological condition.
*Conclusion:* The initiation of VA-ECMO at our center for treatment of refractory cardiac arrest and cardiogenic shock yielded a high proportion of survivors and favorable neurological outcomes.


## 1. Introduction

Veno-arterial extracorporeal membrane oxygenation (VA-ECMO) provides mechanical circulatory support for end-organ perfusion and has been implemented in patients with refractory cardiac arrest (E-CPR) and cardiogenic shock (E-CS) [1-3]. The therapy has been described as a potential bridge to recovery, longer-term device (e.g. left ventricular assist device), decision (e.g. determination of goals of care), or transplant [2-4]. The use of VA-ECMO is increasing rapidly with a reported increase of 433% over 2006 to 2011 [5]. Although there are currently no RCT's upon which to estimate the efficacy of VA-ECMO for cardiac arrest or cardiogenic shock in comparison to conventional treatment, single-center observational studies of patients treated with VA ECMO suggest there may be benefit [6-9].

VA-ECMO for cardiac arrest, also known as E-CPR, requires cannulation and ECMO initiation during active CPR. A meta-analysis of observational trials investigating E-CPR for in-hospital cardiac arrest (IHCA)

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* Corresponding author at: Vancouver General Hospital, ICU, JPPN2, Room 2438, 899 West 12th Avenue, Vancouver, British Columbia V5Z 1M9, Canada.
*E-mail address:* terri.sun@alumni.ubc.ca (T. Sun).

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reported survival to discharge of 40% [4]. However, studies examining E-CPR for out-of-hospital cardiac arrest (OHCA) have demonstrated variable results [7,10-12]. Several studies have attempted to compare the outcomes of patients treated with E-CPR to those treated with conventional resuscitation therapy, two of which failed to demonstrate a significant survival benefit [13,14] and one that did [15].

VA-ECMO for cardiogenic shock, also known as E-CS, is a treatment for sustained refractory hypotension or end organ hypoperfusion. Single group observational cohorts have reported 30-day survival as high as 80% for E-CS [16], however robust data on outcomes in comparison to conventional care is lacking. Other technologies intended to augment cardiac output, such as intra-aortic balloon pumps (IABP), also showed promise in observational cohorts [17] and were implemented widely, however upon evaluation in a randomized control trial, failed to show effect on mortality [18].

Given the costly and resource-intensive nature of this technology, it is prudent to evaluate efficacy and outcomes prior to widespread use. To date, there is relatively sparse data surrounding the outcomes of mechanical cardiac support, specifically VA-ECMO for E-CPR and E-CS [6,19-23]. We sought to report on the utility and outcomes as they relate to survival without disability, associated with the implementation of VA-ECMO, in order to add to the growing body of evidence justifying the need for a unified, multi-center randomized controlled trial.

## 2. Materials and methods

### 2.1. Study design and setting

This study is a retrospective review of medical records of patients who underwent VA-ECMO initiation during cardiac arrest and/or refractory cardiogenic shock between April 2009 and July 2015 at Vancouver General Hospital in Vancouver, British Columbia, the province's largest academic quaternary care and level 1 trauma center. Ethical approval was obtained from the University of British Columbia Clinical Research Ethics Board (H15-01008). Informed consent was waived because of the study's retrospective design.

### 2.2. Patient selection

Since April 2009 all patients with successful initiation of ECMO were identified as part of a database maintained by perfusion services (AS). The inclusion criteria for this study was adult patients (≥18 years of age) treated with VA-ECMO for cardiac arrest or refractory cardiogenic shock. Refractory cardiogenic shock was defined as (i) hypotension refractory to full conventional management and/or (ii) evidence of inadequate end organ perfusion and/or (iii) evidence of ventricular dysfunction as seen on echocardiogram or under fluoroscopy; all evaluated as per the assessment of the treating clinicians. We excluded: [1] post-cardiotomy patients; and, [2] those who were converted to veno-venous ECMO within 24 h, as they were deemed to be primarily requiring respiratory and not cardiac support (N = 1).

### 2.3. Outcome measures & variable definitions

The primary outcome of this study was survival to hospital discharge with favorable neurological status, as defined by a Glasgow-Pittsburg Cerebral Performance Category (CPC) score of 1–2, which was obtained from clinical chart review [24,25]. Secondary outcomes include hospital and ICU length of stay, duration on VA-ECMO and mechanical ventilation.

We dichotomized the patient cohort by indication for VA-ECMO: [1] Patients were classified as E-CPR if ECMO was initiated for cardiac arrest, defined as cannulation having occurred during active cardiopulmonary resuscitation. If these chest compressions began in a hospital setting (e.g. emergency room, catheterization laboratory, cardiac surgery ICU or general ICU, operating room, general ward), the patient was categorized as an IHCA. If these chest compressions began outside the hospital setting, the patient was categorized as an out-of-hospital cardiac arrest (OHCA). We defined sustained return of spontaneous circulation (ROSC) as when chest compressions were not required for 20 consecutive min [26]. Any duration of time less than that was counted as part of CPR [2]. Patients were classified as E-CS if ECMO was initiated for the purpose of refractory cardiogenic shock. We further described this cohort by whether the patient had a cardiac arrest in the preceding 24 h.

Successful weaning was defined as separation from the ECMO circuit for >24 h (re-insertion or pump re-initiation within 24 h of separation was considered as part of the same ECMO course). All other CPR variables were defined as per the American Heart Association Scientific Statement [26].

### 2.4. Data collection

Data collection was conducted in a non-blinded fashion by two independent medical professionals in adherence to recommended chart review methodology [27], with the exception that data abstractors were aware of study purpose and inter-rater reliability was not determined. Abstractors were trained on a set of 2 records. Meetings of study investigators took place every month to discuss conflicting data and resolve disputes. An a priori created data collection instrument was used for the abstraction of pre-specified variables, generated from review of published ECMO literature. These data were extracted from review of medical records. Missing data was noted. In addition, we examined charts and abstracted data from the medical records of other hospitals that accepted patients in this cohort for additional levels of care.

### 2.5. ECMO system

The on-call cardiac surgeon performed the cannulation for all ECMO initiations, using a percutaneous technique of the femoral artery and vein with 15-21F arterial (Medtronic Bio-Medicus 15, 17, 19 and 21F) and 23-27F venous (Medtronic, Bio-Medicus 23, 25 and 27F) cannulas, typically guided by fluoroscopy and trans-esophageal echocardiogram (TEE). The drainage cannula was preferentially placed within the right atrium to minimize the circuit chatter. Preference was made for smaller arterial return cannulae to minimize the need for a distal limb perfusion (DLP) cannula. An ultrasound guided DLP cannula (Medtronic) was inserted when there was clinical suspicion of limb ischemia. The ECMO circuit consisted of the Sorin Revolution Centrifugal pump and Quadrox oxygenator and coated with Bioline (Maquet). Circuits were primed with a plasmalyte solution. Unless contraindicated, systemic anticoagulation was established in all patients with heparin (70 units/kg, maximum 5000 units), followed by initial infusion rate of 500 units/h titrated to target ACT (180–220 s) (Medtronic ACT Plus) and PTT (50–70 s). Flow was initiated at 4–5 L/min and then maintained between 2.5 and 5 L/min depending on recovery of the native cardiac function and assessment of systemic perfusion. Hemoglobin targets were generally between 80 and 100 g/L and platelet targets were maintained $>50 \times 10^3/\mu L$.

### 2.6. ECMO management

The following describes typical practice for ECMO initiation and management at our institution. When a patient was deemed a potential candidate for ECMO by a treating hospital physician (most frequently the intensivist, cardiologist or emergency physician) the on-call perfusionist and cardiovascular surgeon was contacted, who arrived at the patient bedside as soon as possible. The patient was then assessed for clinical suitability, and if possible, verbal consent from family was obtained in concordance with the patient's advanced directives. Generally, patients were considered suitable candidates if they had (i) a treatable cause of their cardiac arrest or shock, (ii) limited co-morbidities and