Saving life and brain with extracorporeal cardiopulmonary resuscitation: A single-center analysis of in-hospital cardiac arrests

Graham Peigh, BA, Nicholas Cavarocchi, MD, and Hitoshi Hirose, MD, PhD

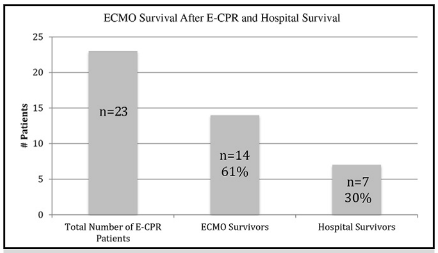
ABSTRACT

Objective: Despite advances in medical care, survival to discharge and full neurologic recovery after cardiac arrest remains less than 20% after cardiopulmonary resuscitation. An alternate approach to traditional cardiopulmonary resuscitation is extracorporeal cardiopulmonary resuscitation, which places patients on extracorporeal membrane oxygenation during cardiopulmonary resuscitation and provides immediate cardiopulmonary support when traditional resuscitation has been unsuccessful. We report the results from extracorporeal cardiopulmonary resuscitation at the Thomas Jefferson University.

Methods: Between 2010 and June 2014, 107 adult extracorporeal membrane oxygenation procedures were performed at the Thomas Jefferson University. Patient demographics, survival to discharge, and neurologic recovery of patients who underwent extracorporeal cardiopulmonary resuscitation were retrospectively analyzed with institutional review board approval.

Results: A total of 23 patients (15 male and 8 female; mean age, 46 ± 12 years) underwent extracorporeal cardiopulmonary resuscitation. All patients who met criteria were placed on 24-hour hypothermia protocol (target temperature 33°C) with initiation of extracorporeal membrane oxygenation. The mean duration of extracorporeal membrane oxygenation support was 6.2 ± 5.5 days. Nine patients died while on extracorporeal membrane oxygenation from the following causes: anoxic brain injury (4), stroke (4), and bowel necrosis (1). Two patients with anoxic brain injury on extracorporeal cardiopulmonary resuscitation donated multiple organs for transplant. The survival to discharge was 30% (7/23 patients) with approximately 100% full neurologic recovery.

Conclusions: The extracorporeal cardiopulmonary resuscitation procedure provided reasonable patient recovery. Extracorporeal cardiopulmonary resuscitation also allowed for neurologic recovery and made multiorgan procurement possible. On the basis of the survival, extracorporeal cardiopulmonary resuscitation should be considered when determining the optimal treatment path for patients who need cardiopulmonary resuscitation. The proper use of extracorporeal cardiopulmonary resuscitation improved the hospital outcomes for patients with in-hospital cardiac arrest. (J Thorac Cardiovasc Surg 2015;150:1344-9)



E-CPR offers means of resuscitation for patients refractory to traditional CPR. E-CPR improved hospital outcomes for patients who had an in-hospital cardiac arrest.

Central Message

E-CPR offers means of resuscitation for patients refractory to traditional CPR. E-CPR improved hospital outcomes for patients who had an in-hospital cardiac arrest.

Perspective

Results from E-CPR at the Thomas Jefferson University show an 30% hospital discharge rate with no major neurologic consequence while previously published CPR survival was less than 20. E-CPR also made multiorgan procurement possible in non-survivors through ECMO support of end-organ function. On the basis of these statistics, E-CPR should be considered when determining a treatment path for patients who have an in-hospital cardiac arrest.

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Cardiopulmonary resuscitation (CPR) is a widely known procedure used to save lives when patients undergo cardiac arrest. However, despite being extensively taught and used, CPR remains ineffective. A meta-analysis has shown that 23.8% of patients who receive out-of-hospital CPR survive to admission, and a mere 7.6% of these patients ultimately survive to be discharged from the hospital.[1] Even when CPR takes place in the hospital setting, the overall survival is not encouraging. It is reported that less than 50% of

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Address for reprints: Hitoshi Hirose, MD, PhD, Department of Surgery, Thomas Jefferson University, 1025 Walnut St, Room 605, Philadelphia, PA 19107 (E-mail: genex@nifty.com).
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Abbreviations and Acronyms

AMI	= acute myocardial infarction
APACHE II	= Acute Physiology and Chronic Health Evaluation II
CPR	= cardiopulmonary resuscitation
CT	= computed tomography
ECMO	= extracorporeal membrane oxygenation
E-CPR	= extracorporeal cardiopulmonary resuscitation
ICU	= intensive care unit
MELD	= Model for End-stage Liver Disease
SAPS II	= simplified acute physiology score II
SOFA	= Sequential Organ Failure Assessment
VT/VFib	= ventricular tachycardia or ventricular fibrillation

patients survive CPR,[2-4] whereas less than 20% of patients survive to discharge.[2,4] These results suggest that when traditional CPR is not effective, alternate means of resuscitation are necessary.

As extracorporeal membrane oxygenation (ECMO) increases in popularity and use, there has been increasing interest in its viability and success when used during CPR (extracorporeal cardiopulmonary resuscitation [E-CPR]). E-CPR provides a method to stabilize hemodynamics and provide end-organ perfusion when traditional CPR is inadequate and the cause of cardiac arrest is reversible. Although many studies have assessed the efficacy of E-CPR in pediatric populations,[5-7] fewer have investigated it in an adult population. The studies of adult populations have assessed the success of E-CPR in adult populations by mortality, and many have not taken end-organ function into account.

In a study that assessed the survival benefits of E-CPR compared with conventional CPR after a witnessed arrest, E-CPR provided a significantly higher return of spontaneous circulation and an approximately 20% increase in survival at discharge.[8] Further studies on E-CPR have shown an increased survival at 1 year[8] and 2 years[9] after discharge when compared with conventional CPR. Many of these studies on adult E-CPR have taken place under optimal conditions in institutions that have designated teams of E-CPR specialists, ready to cannulate patients as a part of the Code Team.[8-10]

Through this investigation, there will be a greater understanding of the benefits to be gained from E-CPR, such as successful hospital discharge with limited neurologic damage or organ procurement in nonsurvivors. If shown to be effective, this study will assert that E-CPR should be considered during in-hospital cardiac arrests.

MATERIALS AND METHODS

From June 2010 to July 2014, a total of 107 adult ECMO procedures were performed at the Thomas Jefferson University. Of those 107 procedures, 23 patients had E-CPR after failing to respond to traditional CPR. All E-CPR candidates were inpatients with a witnessed arrest, and the ECMO team was notified less than 20 minutes after the initial arrest. The Thomas Jefferson University's E-CPR protocol was applied to all patients as follows; the attending physician in charge of a Code Blue determined whether ECMO was feasible within 20 minutes of unsuccessful resuscitation on the basis of the exclusion criteria: patient's age more than 70 years; presence of a patient's "Do Not Resuscitate" orders; whether the patient has an uncorrectable baseline disease such as terminal cancer, advanced coronary artery disease, or a previous neurologic deficit; or the patient has uncontrolled sepsis or bleeding. The code team notified the attending physician on-call in the surgical cardiovascular intensive care unit (ICU), who immediately evaluated the patient's risks and benefits. If all parties were in agreement that ECMO was necessary, the patient was cannulated at the bedside. Perfusionists were called in to set up the ECMO circuit. CPR was continued until ECMO was initiated; all patients receiving E-CPR were started on venoarterial ECMO. The cannulation procedure was followed as outlined by Lamb and colleagues[11] to minimize the risk of excessive bleeding and limb ischemia. Patients who underwent CPR but no longer required CPR during ECMO cannulation were excluded from this study. In-house attending intensivists from the surgical cardiovascular ICU (cardiothoracic surgeons) were responsible for ECMO placement in all patients. Their coverage spanned all regular daytime working hours and 4 of 7 nights with a nocturnist intensivist. Perfusionists were responsible for ECMO circuit setup and available in-house during all regular daytime hours. Perfusionists were also on call during off-hours.

In the Thomas Jefferson University, 100% of the patients treated with E-CPR were placed on a standard hypothermia protocol at 33°C for 24 hours to enhance neurologic protection. Target temperature management was met in all patients via an Arctic Sun (Bard, Louisville, Colo) cooling machine. Clinical neurologic assessment was continued with both cooling and rewarming phases. If a patient had a focal neurologic deficit, uncontrolled seizures, or cerebral oximetry desaturation, the patient was sent for a computed tomography (CT) scan immediately, regardless of whether the patient was on or off ECMO. Once rewarmed, any persistent coma or neurologic deficit necessitated a CT scan. After a positive CT scan for suspected anoxic brain injury, neurology was consulted to evaluate neurologic outcomes, and if necessary, a cerebral perfusion scan was performed on ECMO to diagnose potential brain death. If the patient was deemed to be nonrecoverable, terminal ECMO decannulation was performed after consultations with the family, palliative care team, and organ procurement agency.

Patient demographics, E-CPR survival, survival to discharge, and organ and neurologic recovery were retrospectively analyzed through an institutional review board–approved database (Thomas Jefferson University approval #10D.155). The Acute Physiology and Chronic Health Evaluation II (APACHE II),[12] Model for End-stage Liver Disease (MELD),[13] Simplified Acute Physiology Score II (SAPS II),[14] and Sequential Organ Failure Assessment (SOFA)[15] scores were calculated on the basis of the pre-ECMO, peri-ECMO, and post-ECMO data.

Statistical analyses were performed using chi-square or Fisher exact tests for categoric variables and Student t tests for continuous variables, as appropriate, to identify the risk factors for ECMO death. Similar analyses were performed to identify the risk factors for hospital death among the ECMO survivors. Our sample size was too small for a multivariate analysis; thus, multivariate analyses were not performed. The results were expressed as number with percentage or mean ± standard deviation.

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