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Extra-Corporeal Cardiopulmonary Resuscitation after Cardiogenic Shock: A Case Series of 4 Patients

Ibrahim Mungan*, **Dilek Kazancı, Serdar Yamanyar, Hayriye Cankar Dal** and **Sema Turan**

Department of Intensive Care Unit, Turkey Advanced Speciality Education and Research Hospital, Turkey

Abstract

Cardiopulmonary resuscitation is usually performed after cardiogenic shock and cardiac arrest but conventional CPR (cCPR) might be unsuccessful to provide return of spontaneous circulation (ROSC). Some other methods have been developed to provide and restore circulation for this scenario and Veno-arterial (VA) Extra-corporeal membrane oxygenation (ECMO) has been safely used in cardiogenic shock, post myocardiotomy cardiac failure and after cardiac arrest for many years. We aimed to present the use of VA ECMO in four cases who had refractory cardiac arrest in different situations during the last 6-month period.

Our patients' primary pathologies are acute anterolateral MI, post-cardiotomy surgery and ischemic heart disease. cCPR started immediately after CA and with the absence of a ROSC, so-called refractory cardiac arrest, eCPR decision was made. Duration of cCPR to eCPR ranged between 15-45 minutes. Although survival rate and outcomes are similar to available literature findings, our cases are small in number to conclude any decision.

The American Heart Association suggests the consideration of eCPR if no blood flow is short and the cause of the cardiac arrest is correctable or amenable to heart transplantation or revascularization. This case study emphasizes the need to develop systematic strategies in usage of eCPR among appropriate patients to optimize the potential for survival.

Keywords

Return of spontaneous circulation, Extra-corporeal membrane oxygenation, Cardiopulmonary resuscitation

Introduction

Cardiogenic shock and cardiac arrest (CA) are life-threatening emergencies with a wide range of etiology. During cardiogenic shock and cardiac arrest oxygen supply and blood perfusion are critically reduced and these physical processes can be corrected by extracorporeal mechanical life support (ECLS) in principle [1]. Extra-corporeal membrane oxygenation (ECMO) is one of the methods used for temporary mechanical support of cardiac or pulmonary function today.

ECMO is an aggressive and invasive method for extra-corporeal cardiopulmonary resuscitation (eCPR) which starts after conventional cardiopulmonary resuscitation (cCPR) has failed to restore spontaneous circulation so-called refractory cardiac arrest (rCA) [2,3]. It has two types of usage and Veno-arterial-ECMO, which is used in eCPR reduces preload and increases the aortic flow and end organ perfusion. By this way ECMO also could protect and preserve the myocardium that provides better survival [4]. The other type, Veno-venous ECMO, was mainly used with lung-protective ventila-tion for treatment of acute respiratory distress syndrome and respiratory failure without cardiac failure [1].

ECMO is used as a *bridge-to-recovery* approach in patients with severe cardiogenic shock from myocardial infarction whereas it is employed as a *bridge-to-decision tool* in resuscitated patients as further therapies are postponed until awakening of the patient allows for estimating neurological recovery and eligibility [1].

A great advantage of ECMO is that all parts are transportable, and cannulation may be performed nearly ev-

erywhere. Another superiority to other ECLS systems is that once ECMO is running, the patient can be transferred with the whole unit [5]. Outcomes based on survival and neurological function of rCA patients treated with ECMO are mainly dependent on the expertise of the ECMO team (in technical skills for implantation and, especially, in intensive care) and a careful selection of patients [3]. We present 4 cases of patients who developed cardiac arrest in-hospital manner and cCPR failed so the decision was made to use eCPR by ECMO team.

Case Reports

Case 1: A 52-year-old man was diagnosed as acute anterolateral myocardial infarct and he was referred to cardiology department for coronary angiography immediately. During the procedure the patient suffered incessant ventricular tachycardia and then asystolic cardiac arrest that necessitates urgent intervention with ECMO. Cardiovascular surgery placed ECMO cannulas and the patient was transferred to the operating theatre. He became stable with ECMO and due to the initial angiographic findings and the patient's clinical characteristics evaluation by the cardiologist and the cardiovascular surgeon team, coronary artery bypass graft surgery (CABG) was decided to perform. As the surgical procedure was successful, surgeons decided to start weaning procedure from ECMO device intraoperatively. But weaning trials in the operating room was abortive so surgeons postponed weaning procedure. Anticoagulation with heparin, which was a short acting agent, was paused during surgery and monitored by activated clotting time (ACT). Heparin was not antagonized during surgery and operation time was shortened to prevent thrombosis risk. 4 hours after the surgery heparin treatment was continued and ACT was maintained above 150-200 seconds.

The patient was kept on ECMO for the next 48 hours and weaning was successful. During ECMO therapy, he was sedatized with Dexmedetomidine and Remifentanil. The patient did not develop any ECMO-related collateral effect or complication. After decannulation of the patient intraaortic balloon pump (IABP) was replaced to augment coronary circulation. 5 days safter IABP was also removed but the patient was dependent to mechanical ventilation. 67 days after surgery, he was weaned from mechanical ventilation and discharged from intensive care unit (ICU) without any neurological sequelae. Prolonged mechanical ventilation was dependent to both acute respiratory infection, which was developed after the surgery and unsuccessful weaning trials probably due to the neuromuscular weakness.

Case 2: A 70-year-old man was developed CA 3 days after coronary bypass surgery and cCPR started immediately. As cCPR was unsuccessful to return of sponta-

neous circulation ECMO device was replaced and the patient was transferred to the operating theatre. During ECMO implantation transthoracic echocardiography (TTE) was done and pericardial tamponade was detected. The patient was not heparinized during the procedure and fresh frozen plasma (FFP) was given to maintain pro and anticoagulation balance but despite all the interventions intraoperative bleeding was continued and the patient ceased.

Case 3: A 41-year-old woman was diagnosed as acute anterolateral myocardial infarct and she was referred to the cardiology department for coronary angiography immediately. 24 hours after coronary angiography intervention she suffered incessant ventricular tachycardia and then asystolic cardiac arrest that necessitates urgent intervention with ECMO. She was hemodynamically stable with ECMO device, but metabolic acidosis and post-MI ventricular dysfunction worsened general status. Prerenal and renal acute kidney injury (AKI) due to the altered renal perfusion, systemic inflammatory response and nephrotoxic agents (contrast material which was used during angiography) were suspected for the develoment of metabolic acidosis. Renal replacement therapy was started- without $NaHCO_3$ replacement- immediately but low perfusion signs continued to deteriorate. Unfortunately medical interventions failed and the patient died 24 hours later.

Case 4: A 70-year-old man was diagnosed as left ventricular heart failure (with ejection fraction 21%) and prepared for surgery. He had been receiving dialysis in a routine basis due to chronic renal insufficiency and in the last hemodialysis session, he developed ventricular fibrillation and cCPR started immediately. Failure of cCPR led to eCPR decision and he was transferred to the operating theatre with ECMO device. After successful surgery, he went CABG and temporary Left ventricle asist device (LVAD) implantation, he was transferred to the ICU. Ionotropic agents were continued in maximal doses (dopamine, dobutamine and norepinephrine) but deterioration in ventricular function leads to low cardiac output syndrome (LCOS) and died 6 hours after the surgery.

Discussion

ECMO is a very effective tool for maintaining and improving systemic circulation and provide gas exchange. It is used as a mechanical support in cardiogenic shock and cardiac arrest [1]. The goal of the ECMO usage is myocardial rest while protecting end organ perfusion and supporting good neurologic function after course. In resuscitated patients ECMO may be used for bridge-to-decision or transfer the patient to definitive solution like surgery or percutaneous coronary intervention (PCI)

Table 1: Demographic and intervention summary of cases.

	Case 1	Case 2	Case 3	Case 4
Age	52	70	41	70
Etiology	CA during catheterization	Postcardiotomy failure	CA during catheterization	Ischemic disease
Rhythm disturbance	Incessant ventricular tachycardia	Incessant ventricular fibrillation	Incessant ventricular tachycardia	Asystole
cCPR to ECMO (duration of time)	15 min.	37 min.	45 min.	41 min.
No flow time	2 min.	4 min.	3 min.	4 min.
Mortality time	None	1 hr	24 hr	6 hr
Intervention	Coronary bypass surgery	Reoperated	Stent	Coronary bypass surgery
In-hospital stay (after ECMO)	67 days	1 hr	1 day	6 hr

Abbreviations: cCPR: Conventional cardiopulmonary resuscitation; ECMO: Extracorporeal membrane oxygenation.

Table 2: Refractory cardiac arrest algorithm (CPR ≥ 30 min) taken from Brunner, et al. [8] (Modified from the book Extracorporeal Membrane Oxygenation - Advances in Therapy. 2016. This publication is an open Access publication, available on intechopen. com).

ECMO alarm criteria	
Indications	Contraindications
No-flow ≤ 3 min.	No flow > 5 min.
Or immediate CPR by professional	
Or signs of life per CPR	
Or hypothermia	
Age ≤ 65 years	Obvious sign of death
First rhythm: Shockable rhythm	Comorbidities lead to futility
EtCO$_2$ ≥ 10 mmHg under CPR	Time from cardiac arrest to ECMO > 100 min.
Projected arrival at the hospital ≤ 60 min.	

and the available literature showed that it is sufficient to ensure systemic circulation in refractory CA [1,6]. In our cases ECMO was used as a bridge-to-treatment (surgery or PCI).

Patients included in the eCPR studies showed CA from different etiologies and similarly our patients primary pathologies are acute anterolateral MI, post-cardiotomy surgery and ischemic heart disease. In these studies, the in-hospital survival rate showed a great variability, ranging from 6-59%, that can be linked to several factors like differences in population selection, etiology of CA, duration of cCPR etc. [3]. Only one patient survived to hospital discharge (25% of cases) but non-survivors were older than previous studies. Demographic and intervention summary of cases are given in Table 1, but small sample size obstructs any assumption about variables related to mortality.

In our patients' situation cCPR started immediately and with refractory cardiac arrest eCPR decision was made. Duration of cCPR to eCPR differs from 10 to 60 minutes among studies [7] and our patients' cCPR duration time ranges between 15-45 minutes as it is shown in Table 1. Our patients' situations fulfilled indications -except age factor-which were explained in refractory cardiac arrest algorithm in Table 2 [8].

In 2015, the International Consensus on Cardiopul-monary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations by the International Liaison Committee on Resuscitation (IL-COR) recognized eCPR as an advanced alternative for refractory CA [9]. Meanwhile it has been recommended by The American Heart Association (AHA) that eCPR should be considered for in-hospital patients in CA when the duration of the no-flow arrest is brief and the condition leading to the CA is reversible (e.g. drug intoxication or hypothermia) or suitable to heart transplantation or revascularization [2,10]. Our patients' situations fulfill this criteria, but the decision on whether an ECMO should be implanted in a single patient is still a clinical challenge in clinical practice because it is based on clinical data and on the clinical judgment and experience of the ECMO team and it has to be taken in quite a short time [3]. Our study is a case series report and an observational study without any interruption to ECMO team. In-hospital rCA eligible for further treatment were choosen by ECMO team and monitored via lactate level, lactate clearance, and troponin level.

Renal dysfunction is described as quite common in ECMO patients, most of them because of cardiogenic shock, and it represents an independent risk factor for in-hospital mortality [11] Renal dysfunction was also developed in our patients. The prolonged cerebral hypoperfusion problem may be solved by early initiation of eCPR

with Veno-arterial ECMO and there is evidence supporting that extracorporeal cardiopulmonary resuscitation tends to be superior to cCPR in improving neurological outcomes at 3-6 months in patients with and in-hospital cardiac arrest [12,13].

It was emphasized that the outcomes of CA patients treated with ECMO are mainly dependent on the expertise of the ECMO team and a careful selection of patients. ECMO implantation in CA patients is strictly linked to the 'clinical selection of patients' and because of that it can be considered a clinical challenge [3]. The recent Institute of Medicine report on cardiac arrest care states that ECMO is an emerging technology which has promise in improving cardiac arrest care, so it should be researched and developed [10].

A meta-analysis performed by Cardarelli, et al. in 135 patients in 17-year period of the study showed a hospital survival rate to discharge with eCPR of 40% [14]. We present four cases and one of them made a complete recovery without any neurological sequelae counting 25% survival rate. This reported case is particularly prominent because ECMO was used in-hospital cardiac arrest case and two days later, weaning from ECMO was possible. The other patients in this study, non-survivors, were older and cCPR to ECMO (duration of time) were prolonged. As we mentioned before the count of our study was small to make any conclusion. Nevertheless, this study emphasizes the need to develop systematic strategies in usage of eCPR among appropriate patients to optimize the potential for survival.

Disclosure of Interest

The authors declare that they have no competing interest.

In all cases informed consent had been obtained from patients' relatives prior to admission.

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