Extracorporeal Cardiopulmonary Resuscitation for Out-of-Hospital Cardiac Arrest

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KEY WORDS: cardiac arrest, out-of-hospita, cardiopulmonary resuscitation (CPR), extracorporeal membrane oxygenation (ECMO)

IMAJ 2016; 18: 61–62

Out-of-hospital cardiac arrest (OHCA) is a common occurrence affecting about 420,000 people annually in the United States and many more worldwide. Despite improvements in cardiopulmonary resuscitation (CPR), the overall prognosis remains low. Thus in a large cardiac arrest registry (CARES) including 31,689 OHCA events, the rate of survival to hospital discharge among events of presumed cardiac etiology was 9.6% [1].

Extracorporeal membrane oxygenation (ECMO) technology has advanced significantly and is now more widely available as a therapeutic option for the short-term support of a number of life-threatening conditions, including severe acute respiratory failure, acute myocarditis, as a bridge to lung or cardiac transplantation, and for cardiogenic shock [2]. In our hospital more than 200 adult patients have been treated with ECMO since 2009, with an overall prognosis of 57% survival for cases with primary respiratory etiology and 58% for primary cardiac etiology.

Recently, increasing reports citing the use of ECMO in the setting of cardiac arrest, so-called extracorporeal CPR (ECPR), have appeared in the literature. We report the first known case in Israel where this technology was used as a bridge to definitive therapy in a patient presenting to the emergency room with resistant ventricular fibrillation.

PATIENT DESCRIPTION

A 55 year old man collapsed in the street after complaining of sudden-onset chest pain and shortness of breath. Cardiac resuscitation was started almost immediately by bystanders and continued following the arrival of a specialized team of paramedics a few minutes later. In addition, tracheal intubation was performed and ventilation commenced. An electrocardiograph (ECG) was compatible with ventricular fibrillation (VF) and the patient was defibrillated with transient recovery of cardiac circulation. The patient was then transported to the emergency department (ED) of the Rabin Medical Center while continuing to receive external mechanical cardiac compression (AutoPulse, ZOLL Inc, Chelmsford, MA, USA). A new episode of VF occurred immediately after admission and CPR with external mechanical cardiac compression was continued together with multiple defibrillations and anti-arrhythmic therapy. Due to refractory VF and the absence of return of spontaneous circulation (ROSC) despite a further 20 minutes of ACLS (advanced cardiovascular life support), a decision was made to initiate ECPR in the ED. Peripheral veno-arterial access was obtained using a 21 French arterial cannula and a 25 French venous cannula (Cook Medical, Bloomington, IN, USA). A Maquet Rotaflow centrifugal pump and a Quadrox oxygenation system (Maquet Cardiopulmonary, Rastatt, Germany) were used to complete the ECMO circulation. Time from arrival in the ED to connection to ECMO was 45 minutes. The blood flow was set at 5 L/min with a fraction of inspired oxygen of 1.0. The patient gave immediate signs of awareness with a return to sinus bradycardia of 40/min. Initial laboratory investigations revealed an arterial pH of 6.9 with a serum lactate level of 120 mmol/L. The temperature of the ECMO system was maintained at 34ºC during the first 24 hours. Intravenous anticoagulation with heparin was initiated and continued during the ECMO procedure with the aim of achieving a partial thromboplastin time (PTT) of 55–65 sec. The patient was transported to the angiography suite while continuing to receive ECMO support. Cardiac catheterization revealed occlusion of the right coronary artery as well as an "in stent" occlusion of the circumflex artery. Angioplasty was performed to both arteries and an intra-aortic balloon pump (IABP) was then inserted to prevent any increase of LV afterload under ECMO. The patient was then transferred to the cardiothoracic intensive care unit (ICU).

A detailed history obtained from the patient's family revealed that he was known to suffer from ischemic heart disease with moderate to severe LV dysfunction and had undergone stenting of the circumflex artery a few years previously. In addition, he received chronic oral anticoagulation therapy due to factor V Leiden deficiency.

The patient returned to full consciousness on the second ICU day but required sedation due to motor disquiet. Serial echocardiography performed during the first week after ICU admission revealed an immobile heart with complete akinesia of both ventricles. Three days after admission he developed hemorrhagic shock, which was shown to be the result of intra-abdominal bleeding. An urgent explorative laparotomy revealed bleeding from the spleen, which was removed. His hospital course was further complicated by transient acute renal failure requiring continuous renal replacement therapy from which he made a complete recovery. A percutaneous tracheostomy was performed one week after admission. Neurological examination on day 8 revealed a left hemiparesis and a computed tomography (CT) scan of the brain confirmed a right cortical infarct. The patient improved steadily and made a full neurological recovery. The IABP was removed on day 11 and he was progressively and successfully weaned from ECMO on day 15. He was subsequently weaned from the ventilator and discharged to a rehabilitation center on day 65; 2 weeks later he returned to his home. At that time, his cardiac function had returned to baseline without clinical evidence of cardiac failure.

COMMENT

We present the first known case in Israel of a patient with an OHCA unresponsive to CPR successfully managed with ECPR, which included mechanical chest compression, percutaneous cannulation for ECMO, therapeutic hypothermia, and percutaneous coronary intervention (PCI).

The use of ECPR in the setting of unresponsive CPR has several advantages, including the generation of a circulation to provide sufficient oxygen to the brain and other organs and increasing the time window for identification and treatment of reversible underlying causes of the cardiac arrest. In addition, the early introduction of therapeutic hypothermia may attenuate the severity of ischemic reperfusion injury.

Selection of patients who may benefit from ECPR is crucial in order to optimize expensive and staff-intensive resources. Currently suggested criteria include a witnessed cardiac arrest with a no-flow period of < 5 minutes, absence of ROSC during at least the first 15 minutes after hospital arrival despite conventional CPR, and time from arrest to initiation of ECMO flow < 60 minutes [3]. In addition, the condition leading to the cardiac arrest should be reversible (e.g., accidental hypothermia or drug intoxication) or amenable to revascularization (e.g., acute myocardial infarction), surgical intervention (e.g., massive pulmonary embolism) or heart transplantation (e.g., myocarditis). The procedure requires a multidisciplinary dedicated team, as in our hospital, including critical care physicians, ECMO technicians and cardiologists. Furthermore, a dedicated ECPR trolley containing all materials required for the procedure is essential. Additionally, the performance of high quality CPR, starting at the site of the OHCA and continuing during transport to the ER, is essential for success of the process. While mechanical chest compressions have not been shown to be superior to manual chest compressions, it has been found that when used in the context of ECPR, continuous mechanical devices provide for better overall rates of compression [4]. In addition, during transport, mechanical devices may deliver more effective compressions as well as increase the safety of ambulance personnel in a moving vehicle.

Survival rates for ECPR following OHCA have shown conflicting results. Thus, 45% of patients (5/11) with refractory OHCA survived to discharge with full neurological recovery in the CHEER trial, while a Japanese study of 1282 cases of OHCA reported an overall survival of 26% and in a French study of 51 patients only 2% were alive at 28 days [4]. The differences in outcome may be explained at least in part by the time from collapse to initiation of ECMO, i.e., the shorter the time the better the likely outcome. A real concern with the use of ECPR is that while cardiorespiratory function may be restored, patients may be left with significant neurological deficits due to prolonged resuscitation. However, while outcome results show that up to one-third of non-survivors may indeed die from post-anoxic brain damage, these patients generally have a very short hospital stay [4].

Our patient manifested many of the known complications of this procedure. These include bleeding (3–59%), intra-abdominal bleeding (related to anticoagulation) from a laceration of the spleen (possibly related to mechanical compression), lower limb ischemia (1.5–21%) and stroke (15.4%) [5]. In addition, our patient developed acute renal failure requiring renal replacement therapy from which he made a complete recovery.

Clearly, ECPR is not easy to establish, requires highly trained personnel who are readily available, and is costly. However, as is being increasingly shown, ECPR appears to be a feasible and effective therapy for these most critically ill patients.

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"Think like a wise man but communicate in the language of the people"

William Butler Yeats (1865-1939), English poet, dramatist, essayist, and Nobel laureate