Extracorporeal Membrane Oxygenation-assisted Cardiopulmonary Resuscitation for an In-hospital Cardiac Arrest Patient

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SUMMARY

Extracorporeal membrane oxygenation (ECMO) is used as a resuscitative tool for cardiogenic shock or cardiac arrest patients in the emergency department. It provides a better outcome for an in-hospital cardiac arrest (IHCA) patient, even if the patient has received prolonged cardiopulmonary resuscitation. We present the case of a 44-year-old female IHCA patient who presented to the emergency department with sudden onset of chest pain and cold sweating. Cardiac arrest occurred approximately 20 minutes after she arrived at the emergency department. Spontaneous heart beating returned immediately after cardiopulmonary resuscitation, and the patient was then supported by quickly applying ECMO. Thereafter, primary percutaneous transluminal coronary angioplasty was performed by a cardiologist. The patient received ECMO support for a total of 12 days. There were no major complications noted during the hospital stay. In conclusion, the use of ECMO to support cardiopulmonary function during cardiopulmonary resuscitation can improve the chance of survival in cases of IHCA that have better central nervous function after being weaned from ECMO. Shorter cardiopulmonary resuscitation duration and less organ damage may predict a better outcome in these patients. [International Journal of Gerontology 2010; 4(2): 99–103]

Key Words: cardiopulmonary resuscitation, extracorporeal membrane oxygenation

Introduction

Extracorporeal membrane oxygenation (ECMO) support has been used for resuscitation since the 1960s, and it provides temporary cardiopulmonary support for patients with diseases that are expected to be reversible[1]. There are two modes of ECMO: venoarterial mode, which provides hemodynamic support, and venovenous mode, which provides pulmonary support. In the emergency department (ED), ECMO plays an important role in treating in-hospital cardiac arrest (IHCA) patients, and improves the overall survival rate to discharge from 13.4–17% to 34.1%[2–4]. In addition, ECMO-assisted resuscitation may also extend the acceptable duration of cardiopulmonary resuscitation (CPR), leading to higher survival rates, which in turn gives the opportunity to provide further intervention[4]. We may predict a better outcome of survival and weaning rate by evaluating the central nervous system and renal function in the first 24 hours after resuscitation, and the duration of CPR and etiology of cardiac arrest may affect survival[4].

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Case Report

A 44-year-old female presented with chest pain and cold sweating for 30 minutes. Two days previously, she had

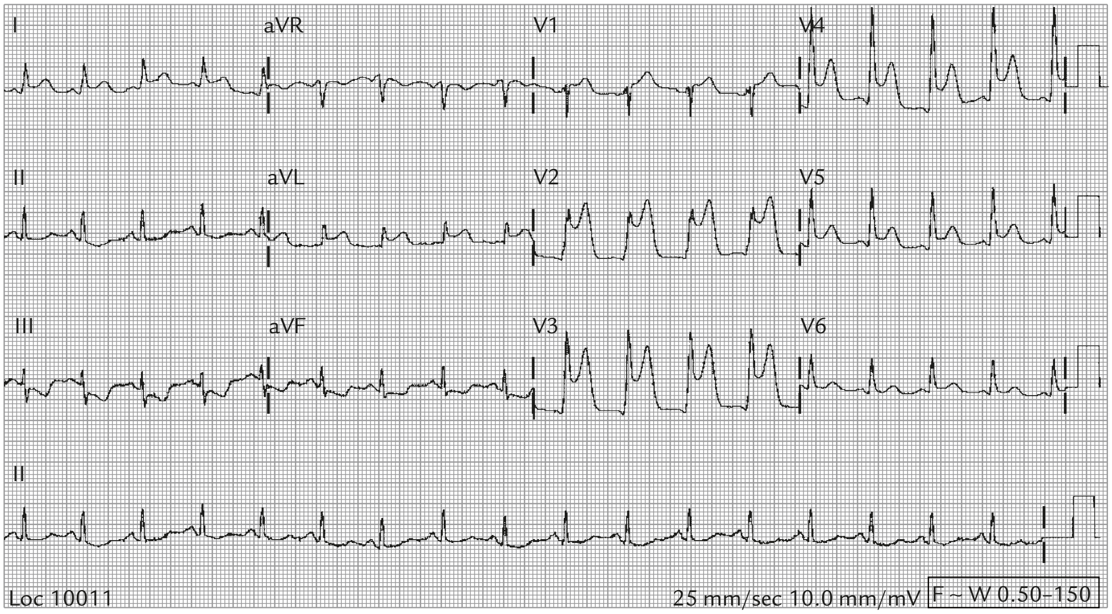

Figure 1. Initial electrocardiogram: ST-segment elevations in leads V_2 to V_5.

just been discharged from the cardiovascular department with a diagnosis of acute myocardial infarction, a consequence of a triple vessel occlusion. She had received percutaneous transluminal coronary angioplasty at the previous admission, followed by implantation of stents inside the three main coronary arteries. In addition, she had a 5-year history of hypertension and hyperlipidemia, without regular medical control.

Initially, the patient visited our ED with clear consciousness. Her vital signs were as follows: body temperature, 36.0°C; pulse rate, 106 beats/min, respiratory rate, 20 breaths/min, and blood pressure, 83/57 mmHg. Physical examination revealed tachycardia and tachypnea with clear breath sounds bilaterally. The first electrocardiogram showed ST-segment elevations in leads V_2 to V_5 (Figure 1), and the values of cardiac enzymes, including creatine phosphokinase, creatine kinase MB, and troponin I, were within the normal range. Twenty-four minutes after she presented to the ED, the patient was found to have nausea and vomiting, and became progressively more drowsy. Unfortunately, pulseless electrical activity followed, leading to an immediate start of CPR. During her resuscitation, there were fewer responses to defibrillation applied during ventricular tachycardia, which occurred once, and ventricular fibrillation, which occurred three times. Spontaneous circulation with hypotension returned, but only persisted for a few minutes. She was considered for treatment with ECMO to help restore her cardiopulmonary function, and ECMO was quickly applied through the femoral vessels for at least 90 minutes after this emergency episode. Return of spontaneous heart beating was noted a short time after ECMO support. Primary percutaneous transluminal coronary angioplasty was then performed, and revealed diffuse coronary vessel spasm with some thrombosis in the right coronary artery. No obvious stenosis was found. Repeated electrocardiogram showed sinus tachycardia and complete right bundle branch block (Figure 2). The patient was then sent to the intensive care unit for further care.

In the intensive care unit, an intra-aortic balloon pump was used to decrease the afterload and increase the perfusion of the coronary arteries. Inotropic agents including dopamine and dobutamine were given to maintain adequate blood pressure. Heparin dosage was adjusted according to the activated clotting time. A central venous catheter and Swan-Ganz catheter were inserted to monitor fluid status, cardiac output and heart chamber pressure, and thus monitor heart contractile function indirectly. The ECMO flow and speed settings were regulated according to the arterial blood gas and blood pressure. Biochemistry was checked daily, including sodium, potassium, calcium, and cardiac enzyme levels. Blood products, such as packed red blood cells, fresh frozen plasma and platelets, were transfused as necessary.

Acute pulmonary edema was found during hospitalization. We used diuretics to maintain adequate urine

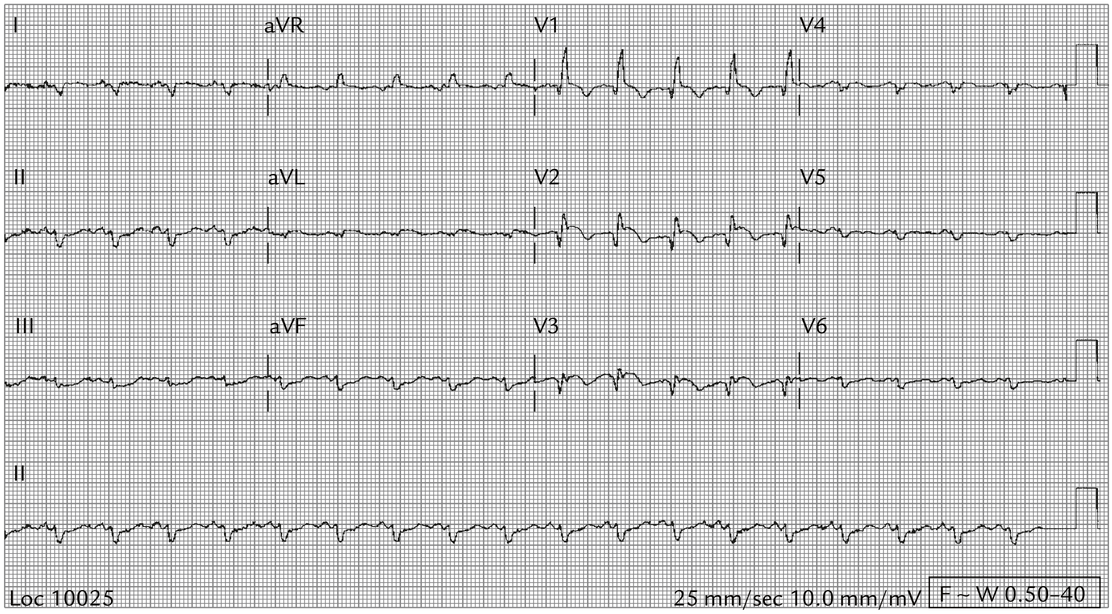

Figure 2. Repeated electrocardiogram after extracorporeal membrane oxygenation and percutaneous transluminal coronary angioplasty: sinus tachycardia and complete right bundle branch block.

output and edema control. During the period of ECMO use, the patient was sedated with midazolam and she could respond to some questions by blinking her eyes. A prophylactic antibiotic was used to prevent catheter-related infection, and a blood culture showed no bacterial growth. Her electrocardiogram showed severely impaired left ventricle systolic performance, diastolic compliance, and regional wall motion abnormality, and her renal function progressively worsened (creatine, 1.9–3.0 mg/dL). During this hospital stay, there were no severe ECMO-related complications found, including hemorrhage, thromboembolism or vessel injuries. Unfortunately, ECMO was refused by the patient's family and removed on the 12th day for financial reasons, after which the patient died.

Discussion

ECMO during CPR improved the outcome for patients who had a cardiac arrest or shock when it was used in an emergency[5,6], especially for the main causes of cardiac arrest, including acute coronary infarction, pulmonary embolism, and cardiomyopathy[7]. ECMO can provide immediate cardiopulmonary function support to preserve tissue perfusion and to decrease myocardial loading[8]. The use of ECMO during CPR in the ED requires specialized equipment and well-trained surgeons, physicians, nurses and therapists, who are available 24 hours a day. This is also an expensive and invasive procedure, so the criteria for ECMO use varies widely from institution to institution. Exclusion criteria in most studies are age above 75 years, severe irreversible brain damage, malignancy, and uncontrolled infection or coagulopathy[4,8,9]. According to the 2005 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care, ECMO during CPR should be performed for IHCA patients who have reversible underlying diseases or have an opportunity for further intervention such as heart transplant[7,10].

IHCA carries a high risk of mortality and morbidity in the ED. In conventional CPR for cardiac arrest patients, the outcome worsens if the duration of resuscitation is longer than 10 minutes[11–13]. One study revealed that ECMO during CPR was beneficial for short-term and long-term survival of patients with IHCA of cardiac origin, who received conventional CPR for more than 10 minutes[9]. The study also identified that the duration of CPR and etiology of cardiac arrest may influence survival[9]. Acute coronary syndrome and obstructive lesions had both poor weaning and survival rates[9]. The organ damage after arrest in the first 24 hours may predict the outcome, and organ dysfunction scores of renal and central nervous function were used for evaluation[8,9]. Previous studies have presented some biochemical findings to predict the outcome during ECMO support. Creatine kinase, creatine kinase MB, aspartate aminotransferase, lactate acid, and renal function during ECMO support were predictive of weaning and survival[8]. Some studies had discussed the correlation with initial rhythm, defibrillation and outcome[4]. They reported that the most common initial rhythm was pulseless ventricular tachycardia or ventricular fibrillation[4,9], and most of the patients with these rhythms were defibrillated. These patients may have lower mortality than those showing asystole or pulseless electrical activity as their initial rhythm[9].

Some studies mentioned that ECMO support may extend the duration of CPR, and that the average duration was around 55.7 minutes[4,8]. The successful weaning rate was 58.4% and the survival-to-discharge rate was 34.1%[4]. If the CPR duration was longer than 1 hour, the weaning rate and survival rate decreased markedly[4,9]. In addition, the CPR duration was shorter in survivors (average duration, 43.2 minutes) than in non-survivors (average duration, 62.1 minutes)[4,8,14].

More than half of the patients received subsequent interventions, such as coronary angioplasty, surgery or transplantation[4]. The correlation of subsequent interventions with survival is still controversial because of a lack of evidence[4,8]. In addition, it is noted that the duration of CPR is correlated with neurologic dysfunction[4,8,14]. Compared with survivors who received conventional CPR, most survivors who received ECMO support had good cerebral performance category status at hospital discharge, even if they received prolonged CPR[9].

In the ED, ECMO support for out-of-hospital cardiac arrest patients is still controversial because of the uncertain time of arrest. The survival-to-discharge rate is low, and the patients have poor cerebral performance category status[9]. In contrast, one recent case report showed a successful outcome when ECMO was applied to a 37-year-old out-of-hospital cardiac arrest male who received prolonged CPR, and he was discharged without neurologic complications[15]. During his resuscitation, he had refractory ventricular fibrillation and did not regain spontaneous circulation after treatment with CPR, defibrillation or medication[15]. The patient received ECMO support after CPR for 2 hours in total, and he then received primary percutaneous transluminal coronary angioplasty with intravascular stent insertion for his totally occluded left anterior descending coronary artery[15]. Therefore, ECMO may be helpful for those patients, whose cardiac rhythms are restored transiently but not successfully maintained because of recurrent ventricular fibrillation. The timing of ECMO use for out-of-hospital cardiac arrest patients should be discussed in further studies[15].

In conclusion, ECMO during CPR may provide a better outcome for IHCA patients if ECMO is available within an acceptable duration (at least 60 minutes) after arrest. The CPR duration and organ damage have a great impact on survival, so we should try to shorten the duration between decision-making and ECMO application. Well-trained practitioners and equipment from different departments should be integrated, and the patient selection criteria should be clearly established for ECMO use.

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