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Case Report

Use of Extracorporeal Membrane Oxygenation for Optimal Organ Donation

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We report a case of extracorporeal membrane oxygenation (ECMO) support for donor organ preservation in a brain-dead patient following out-of-hospital cardiac arrest. A 43-year-old male patient was referred to the emergency department after an out-of-hospital cardiac arrest caused by ventricular fibrillation. Spontaneous circulation was restored after 8 minutes of cardiopulmonary resuscitation. ECMO was implemented because of hemodynamic deterioration. The patient then underwent coronary angiography and was implanted with a drug-eluting stent because of occlusion at the proximal portion of the right coronary artery. After 144 hours, brain death was established, and ECMO support for optimal oxygen delivery was sustained until organ retrieval after consent for donation was received from the family. Liver and kidneys were successfully transplanted to three recipients, respectively.

Key Words: brain death; extracorporeal membrane oxygenation.

Organ transplantation is limited by the shortage of eligible organs. Organ donation after cardiac or brain death is a valuable option in many countries as the deficit between demand and supply widens.[1] However, after brain death donor organ function becomes impaired with increasing time from the determination of brain death to cold preservation of the donated organs.[2] In particular, in brain-dead patients with cardiorespiratory failure such as acute myocardial infarction and acute respiratory distress syndrome, it is difficult to protect the donor's organs from warm ischemic damage until organ procurement. Herein, we report a case of veno-arterial extracorporeal membrane oxygenation (ECMO) support for organ preservation of a potential donor with brain death following an out-of-hospital cardiac arrest due to ventricular fibrillation with acute myocardial infarction.

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Case Report

A 43-year-old man was admitted to the emergency department with out-of-hospital cardiac arrest due to ventricular fibrillation. He was intubated during the resuscitation and spontaneous circulation was restored after performance of cardiopulmonary resuscitation for 8 minutes. His initial blood pressure was 50/24 mmHg and his pulse rate was 80 beats per minute. Electrocardiography revealed complete atrio-ventricular block with ST segment elevation in the II, III, and aVF leads. On admission, laboratory examination revealed a blood urea nitrogen level of 16.3 mg/dl, creatinine of 1.76 mg/dl, aspartate aminotransferase level of 441 U/l, alanine aminotransferase level of 282 U/l, and total bilirubin level of 0.9 mg/dl. In our hospital, implantation of ECMO is performed as an intention-to-treat with hemodynamic ECMO support regardless of interim resuscitation of spontaneous circulation. A femoro-femoral veno-arterial ECMO

was implanted because of hemodynamic deterioration despite use of high-dose vasopressor. Blood flow rate of ECMO was maintained at 3.5 L/min in order to maintain adequate blood pressure and tissue oxygenation. The patient then underwent coronary angiography and was implanted with a drug-eluting stent after thrombus aspiration because of thrombotic occlusion at the proximal portion of the right coronary artery. Final angiographic findings did not show any complications such as dissection, distal embolization or slow flow. The patient was transferred to the cardiac intensive care unit and therapeutic hypothermia was performed for 36 hours. At 14 hours after percutaneous coronary intervention the patient developed fixed and dilated pupils, and his spontaneous breathing stopped. Brain computed tomography showed diffuse brain edema with loss of differentiation in the gray and white matter and obliteration of cerebral sulci and ventricle. After 57 hours, the neurologist suspected brain death based on loss of all brain stem reflexes and electrocerebral silence on electroencephalogram. The potential donor remained hemodynamically unstable despite use of inotrope and vasoactive drugs without ECMO support. Repeat investigations for brain death were performed after 97 hours and 144 hours by an anesthesiologist and neurologist, respectively, and both reported findings consistent with brain death. On hospital day 6, brain death was established by the brain death decision committee and ECMO support for adequate organ preservation was continued until organ retrieval after obtaining consent from his family. After implantation of ECMO the potential donor was maintained with stable vital signs by inotropic support with dobutamine (3 mcg/kg/min), amiodarone (200 mg), and rosuvastatin (20 mg) daily, and carptopril (3.125 mg) three times a day. Just before organ donation, arterial blood gas values showed pH 7.47, PaO_2 84.8 mmHg, PCO_2 30.5 mmHg, HCO_3 21.7 mM, and SpO_2 95.9%. Laboratory findings showed a white blood cell count of 9,860 cells/μl with 69% neutrophils, blood D-lactate of 1.15 mM, blood urea nitrogen level of 25.9 mg/dl, creatinine of 1.75 mg/dl, aspartate aminotransferase level of 57 U/L, alanine aminotransferase level of 74 U/L, and total bilirubin level of 3.5 mg/dl. Mean urine output was 2,500 ml/day. The procedures for organ retrieval were performed under ECMO support over a total time of 3 hours. The warm ischemic times of each kidney and the liver were 32 min, 34 min, and 40 min, and the cold ischemic times were 214 min, 332 min, and 223 min, respectively. The liver and kidneys were successfully transplanted in three recipients.

Discussion

A shortage of organs for transplantation has emerged as a major problem as a result of increasing demand. Brain injury is well established as a cause of death after out-of-hospital cardiac arrest and a previous study showed that 12% of patients with out-of-hospital cardiac arrest met the criteria for brain death.[3] Accordingly, this considerable number of patients with brain death after cardiac arrest may represent a crucial source of organs for transplantation worldwide.[1] However, the function of organs from brain-dead donors with cardiorespiratory failure deteriorates over time from the determination of brain death to cold preservation of the donated organs[2] Traditionally, the strategy for preservation of organ function included invasive hemodynamic monitoring and aggressive use of vasoactive drugs, steroids, and hormone-replacement therapy.[4] However, despite optimal medical treatment, the brain-dead donor can experience hemodynamic compromise as a result of complex physiologic disturbances such as a reduction of myocardial function with diminished levels of circulating thyroxine and severe dehydration caused by diabetes insipidus.[5] Accordingly, ECMO support should be considered in selected potential donors with

Table 1. Case reports of the ecmo use for organ donation

	Current case	Lee JH et al.[2]	Isnardi et al.[5]	Wang et al.[10]
Age	43	49	14	22
Gender	Male	Male	Female	Female
Cause of brain death	Cardiac arrest	Trauma	Drowning	Trauma
ECMO indication				
CPR	Yes	Yes		Yes
Heart and lung support			Yes	
ECMO to donation time	6 day	7 hr 55 min	Immediately	4 hr 10 min
Donation				
Kineys	Yes	Yes	Yes	No
Livers	Yes	No	Yes	Yes

ECMO: extracorporeal membrane oxygenation; CPR: cardiopulmonary resuscitation.

disturbance of tissue perfusion such as a high lactate level who require a high-dose vasoactive drug, and its use is considered both ethical and rational to prevent the failure of organ transplantation regardless of the donor family's intention.

In brain-dead patients, high serum catecholamine reduces ß-adrenergic receptor density, which may increase the risk of graft dysfunction after heart transplantation.[6] Therefore, the exogenous catecholamine dose should be reduced as much as possible and early use of ECMO could decrease the dose of exogenous catecholamines required in brain-dead patients.[7] In general, ECMO is used to maintain hemodynamic support and systemic oxygenation in patients with cardiac or respiratory failure. In previous studies, several cases of ECMO support as a bridge to organ donation have been reported after brain or circulatory death for optimal organ perfusion until procurement. (Table 1) [2,5,8-10] Contrast to previous studies, in our case, the implantation of ECMO was aimed to support hemodynamic deterioration despite use of high-dose vasopressor before brain death was established and ECMO support until organ retrieval was successfully maintained in a brain-dead patient after out-of hospital cardiac arrest. These reports suggest that use of ECMO support might be a valuable option to increase the supply of well-conserved organs. In Korea, organ allocation is controlled by a central transplantation organization and there is a long wait time to obtain consent from the patient's family because a culture of organ donation is not yet established.[2]

In conclusion, we report use of veno-arterial ECMO maintenance as a bridge to recovery before determination of brain death and to decrease ischemic injury of organs after determination of brain death. The maintenance of ECMO support for successful organ donation is a viable approach to increase the donor pool.

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