

## Original Article

# Application of extracorporeal membrane oxygenation in supporting organ transplant donors

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**Abstract:** The aim of this study was to investigate the effects of and summarize our experiences with extracorporeal membrane oxygenation (ECMO) in supporting donors with unstable respiration and circulation before organ transplantation. The data of 4 brain-dead organ donors (DBDs) from September 2012 to August 2013 were retrospectively analyzed. We performed auxiliary emergency ECMO support for 9.5-78 h before their hepatonephric functions were improved to some extent and then donor liver and donor kidneys were successfully obtained. The 4 donors had auxiliary emergency ECMO support for 78 h, 32 h, 9.5 h, and 14 h, respectively, and we obtained homeostasis and improved their hepatonephric functions. Two kidneys were abandoned due to consolidation, but the other 10 organs were successfully transplanted, although 2 recipients exhibited renal delayed graft function (DGF). The 10 recipients were discharged after healing. ECMO can provide effective respiratory and circulatory support to transplant donors, improve organ function, and provide sufficient time for transplantation; thus, it can effectively assist in the current situation of organ donor shortage.

**Keywords:** Extracorporeal membrane oxygenation, brain-dead, donor, transplant

## Introduction

The current global demands for donor organs have been increasing over time, which is in obvious contrast to the relative lack of donor organs. This has become one of the world's problems that urgently need to be solved [1-3]. Chinese organ donation and transplantation work is in its infancy, affected by traditional concepts and non-formal legislation of brain death. Few citizens voluntarily donate their organs after death. In this situation, how to effectively protect and exploit scarce donor organs has become a primary problem faced by health workers [4, 5]. This study retrospectively analyzed extracorporeal membrane oxygenation (ECMO) support of 4 brain-dead organ donors (DBDs) from September 2012 to August 2013, aiming to investigate the roles and summarize the experiences with ECMO in supporting donors with unstable respiration and circulation before organ transplantation [6-10].

## Materials and methods

### Donor information

Among the 4 DBDs, 3 had craniocerebral injury, and 1 had viral brainstem encephalitis. All of

their breathing was maintained with an intubation ventilator. Brain death was determined by one neurologist using the diagnostic criteria of brain death referring to the brain death criteria (adult) (revised) developed by the drafting group of the Health Ministry. After the family members discussed the situation, they decided to abandon the treatment and donate organs. They signed the informed consent for treatment abandonment under the auspices of the Red Cross and completed the organ donation program. During this period, 2 DBDs exhibited very unstable respiration and circulation, and after applying high-dose vasoactive drugs, the laboratory tests showed that their hepatonephric functions were damaged to various degrees, while the other 2 DBDs were relatively stable. Because the involved identification programs took a long time, emergency ECMO support treatment was performed after communicating with their families. The general information and characteristics of the DBDs before ECMO are shown in **Tables 1** and **2**. This study was conducted in accordance with the declaration of Helsinki. This study was conducted with approval from the Ethics Committee of Zhengzhou University.

**Table 1.** General Information of DBDs

DBD	Gender	Age (years)	Cause	Blood type
1	F	56	Brain Trauma	O
2	M	33	Brain Trauma	A
3	M	19	Brainstem encephalitis	O
4	M	43	Brain Trauma	B

DBD: brain-death organ donor.

### *Establishment of ECMO*

The 4 DBDs had intensive care unit (ICU) bedside intubation for ECMO support using the following equipment: a Medtronic Bio-Console 560 ECMO system, and a Carmeda® coated ECMO cuff package and femoral vein catheter (Medtronic Co., Minneapolis, Minnesota, US). The femoral artery and vein were partially cut and exposed from the side with a small puncture injury; then, according to each DBD's body weight and blood vessel size, a catheter of the correct caliber (arterial 15-17 F; vein 17-21 F) was selected. The catheter's position was adjusted, so that the head end of the arterial catheter was placed in the iliac artery and that of the vein was placed at the opening of the inferior vena cava of the right atrium; meanwhile, considering the possibility of lower limb ischemia on the intubation side, one 12 F arterial catheter was placed at the distal femoral artery and connected with the lateral side of the femoral arterial catheter, so that the blood supply of the lower limbs could be met (**Figure 1**) [11]. The cuff package was pre-filled with conventional crystal; then, we replaced the pre-filled liquid with 1 L of HES and protein to maintain ECMO and applied moderate osmotic pressure, as well as conventional veno-arterial ECMO supportive care.

### *Operation management of ECMO*

We continuously infused heparin with a micro pump, and maintained activated clotting time (ACT) at 160-180 s; according to the DBD's body weight and blood pressure; the ECMO flow was adjusted within 2.5-3.8 L/min. According to the dynamic changes of venous oxygen saturation (SvO<sub>2</sub>), the oxygen concentration was adjusted within 40%-80% to maintain SvO<sub>2</sub> at 70 ± 5 mm Hg. We gradually reduced the ventilator's parameters during ECMO and maintained them at minimal amounts. According to the hemodynamics, we gradually and slowly

reduced the doses of vasoactive drugs, administered liver- and kidney-protective drugs, intermittently monitored hepatonephric functions, and adjusted medication types and dosages as appropriate, while applying conventional anti-infection and nutritional support.

### *Monitoring indicators*

We closely observed the changes in hemodynamics and blood gas analysis, gradually adjusted the doses, and monitored parameters such as blood pressure, venous pressure, urine output, and biochemical indicators.

### *Acquisition and processing of donor organs*

During ECMO support therapy, the hepatonephric functions of DBDs were significantly improved, and after they had been assessed and qualified for transplantation conditions by transplant specialists, the donor was transported to the operating room for acquisition of the liver and kidney according to the organ donation processes. We registered the organ information for matching, distribution, and sharing, and the organ transplantation effects were followed up.

## **Results**

### *Auxiliary effects of ECMO*

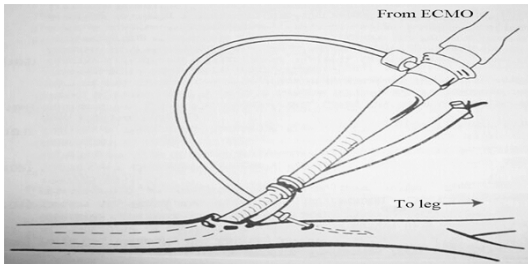
The oxygenation of the 4 DBDs was immediately improved after ECMO, to SO<sub>2</sub> ≥ 98%, with relatively stable hemodynamics, and with the extension of auxiliary time, the vasoactive drugs were smoothly reduced to the lowest maintenance doses or even stopped. DBD 1 and 2 had severe internal environments and hepatonephric dysfunction before ECMO, so their hemodynamics and hepatonephric functions recovered slowly; however, after assistance for 78 h and 32 h, respectively, all indicators were significantly improved (**Figure 2**). The internal environments of DBD 3 and 4 were redressed shortly after ECMO application (9.5 h and 14 h, respectively) before their hemodynamics and hepatonephric functions recovered significantly (**Figure 3**).

### *Acquisition and transplant effects of donor organs*

Among the 4 livers and 8 kidneys obtained, 2 kidneys were abandoned due to consolidation,

**Table 2.** Medication and laboratory indicators of donors (maximum value)

Donor	Dopamine ( $\mu\text{g/kg. min}$ )	Epinephrine ( $\mu\text{g/kg. min}$ )	Norepinephrine ( $\mu\text{mol/L}$ )	Creatinine	ALT (U/L)	Total bilirubin ( $\mu\text{mol/L}$ )
1	18~27	0.22~0.25	0.20~0.25	496	412	105
2	12~20	0.15~0.20	0.13~0.20	339	122	79
3	8~12	0.10~0.13	0.08~0.15	134	89	38.9
4	10~15	0.13~0.18	0.10~0.15	212	101	45.2

**Figure 1.** Schematic of femoral arterial catheterization.

while the other 10 organs were successfully transplanted. Two recipients exhibited renal delayed graft function (DGF), and all 10 recipients were discharged after healing.

### Discussion

In recent years, along with improvements in the national organ transplant laws and regulations, the phenomenon of a shortage of organ donors has become increasingly prominent, while sources such as standard DBDs have not increased.

Partial brain-death increases the sympathetic efferent impulses, thus exponentially increasing catecholamines inside the systemic circulation, which can strongly contract the blood vessels, reducing the blood supply and demanding balance among tissues and organs. It can also directly and indirectly damage the heart, and severe cases can cause cardiac arrest [12].

ECMO is only reserved for critical structures on the basis of conventional cardiopulmonary bypass. In ECMO, blood is drawn outside the body, and then pumped back into the body after oxygenation. It is a short-term cardiopulmonary assistive technology, and its advantages are [13]: 1) to partially replace heart function, effectively maintaining a stable systematic circulation and increased tissue and organ per-

fusion, while greatly reducing the use of vasoactive drugs; 2) through *in vitro* oxygenation, it effectively improves hypoxemia, while reducing the incidence of ventilator-associated lung injuries; and 3) through controllable regulation

through the artificial heart-lung. It can effectively maintain the stability of the internal environment.

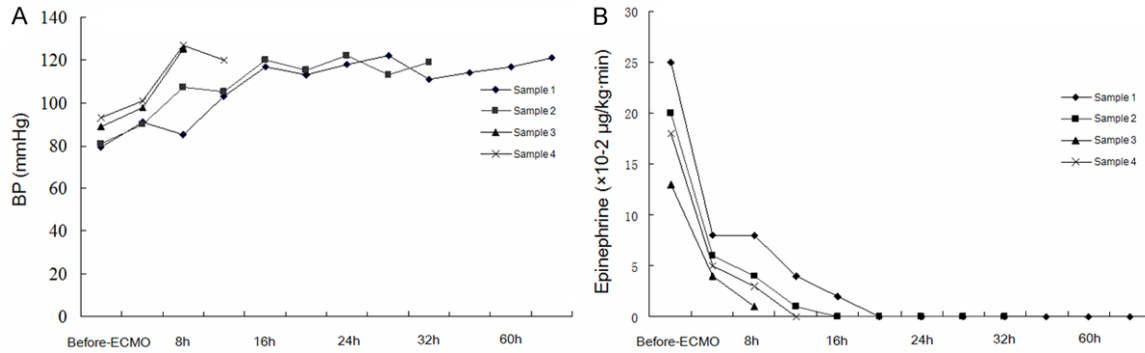
With the maturity of this technology in the respiration and circulation fields in China and abroad, complications have been effectively reduced [14-16] and in recent years, its applications in protecting transplant organs have been gradually developed. This technology can effectively expand the utilization rate of donor organs and improve the transplant success rate and long-term quality of life of recipients. Therefore, it is being increasingly recognized by transplant centers that DBDs with circulatory disorders before donation should receive ECMO assistance as early as possible [17, 18].

In this study, among the 4 DBDs, 2 exhibited serious circulatory disorders, and vasoactive drugs had been used up to the limit before ECMO assistance. Despite this, the relevant organs were already injured, but after up to 72 h of ECMO assistance, their internal environments and hepatonephric functions were improved significantly; however, 1 kidney was ultimately abandoned because of consolidation.

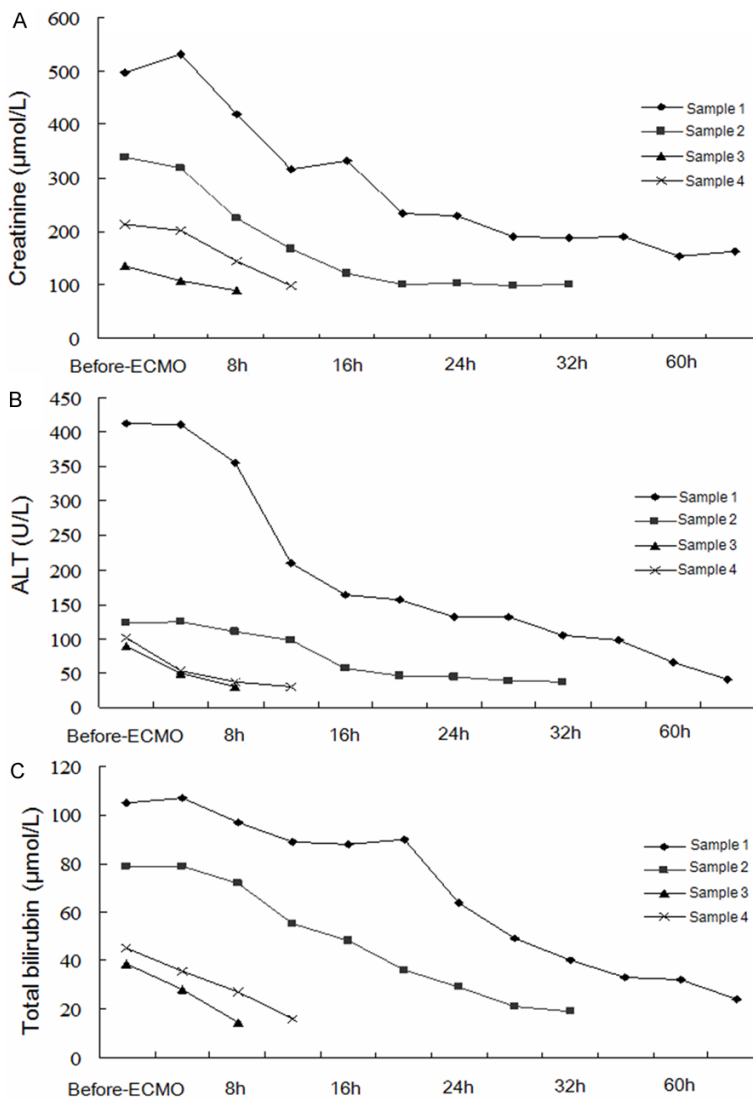
Although the other 2 DBDs did not have severe circulatory disorders, their internal environments had disorders, and their hepatonephric functions had already declined. Considering the subsequent maintenance time, timely ECMO assistance was applied, and after short-term ECMO assistance, the effects were significant.

ECMO is an exogenous assistive technology. Although it has been improved with such technologies as heparin coating and centrifugal pump driving, and its damages to the blood components has been reduced to the minimum, it can still activate complements and induce inflammation, thus indirectly causing further damage to the organs. However, as

## Organ transplant donors



**Figure 2.** Changing curve of blood pressure and epinephrine adjustment. A. Changing curve of blood pressure; B. Changing curve of epinephrine adjustment.



**Figure 3.** Changing curve of creatinine, ALT and total bilirubin. A. Changing curve of creatinine; B. Changing curve of ALT; C. Changing curve of total bilirubin.

shown in this study, this damage can be counter-balanced by the positive “therapeutic” effects of ECMO.

Currently, the applications of ECMO for DBDs are still in the clinical exploration stage, and there are some ethical controversies [19-22], but its effects in protecting donors are significant, and it is believed that with the improvements and perfection of related technologies, ECMO will be widely used in the field of transplantation.

### Disclosure of conflict of interest

None.

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