Clinical prognosis analysis of extracorporeal membrane oxygenation in patients with heart transplantation

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Abstract

Purpose Extracorporeal membrane oxygenation (ECMO) is the primary indication for transplanted right heart failure in transition and postoperative period for heart transplantation patients. This study explored risk factors affecting the clinical prognosis of ECMO through analyzing the clinical data of heart transplantation patients with such condition. **Methods** Data on 28 heart transplantation patients with ECMO obtained from January 2012 to January 2018 in the People's Hospital of Zhongshan City were retrospectively analyzed. **Results** A total of 25 patients (20 male and 5 female) were included in this study. Heart transplantation among patients was performed mainly due to cardiomyopathy (77.8%). Eighteen patients survived and were discharged 18 (72%). Four patients were treated with cardiopulmonary resuscitation before ECMO, and three patients died in the hospital. No differences existed among the surviving and death group donors (N-terminal pro b-type natriuretic peptide [NT-proBNP], creatine kinase-muscle/brain [CK-MB], warm ischemia time of donated heart, cold ischemia time of donated heart, total ischemia time of donated heart, and donator type). Univariate analysis showed that body mass index (BMI), length of stay in intensive care unit (ICU), and cardiopulmonary resuscitation are relevant prognosis factors in applying ECMO for patients with heart transplantation. Multi-factor logistic regression results show that cardiopulmonary resuscitation before ECMO (OR: 49.45, 95% CI [1.37, 1781.6]; $P=0.033$) is an independent risk factor influencing prognosis. **Conclusion** ECMO is an important life support method for patients with heart transplantation before and after the operation. Patients with obesity, poor preoperative cardiac function, and considerable red blood cell transfusions during surgery may influence the prognosis of patients. Extracardiac compression before ECMO of patients is an independent risk factor for their prognosis.

Background

Heart transplantation is the last choice for cardiac patients at the end phase^[1]. Extracorporeal membrane oxygenation (ECMO) is an important choice for patients with refractory cardiogenic shock, and it has been widely used in cardiogenic shock resulting from various factors, such as explosive myocardial inflammation, myocardial infarct, low cardiac output after cardiac surgery, and heart transplantation transition^[2-5]. ECMO is also the main auxiliary support for transplant failure after heart transplantation^[6]. Among the related factors, transplanted right heart failure caused by severe pulmonary vascular disease secondary to pulmonary hypertension is the main indication of ECMO. Previous research indicate that high simplified acute physiology score II before ECMO, diabetic mellitus history, and thrombocytopenia are risk factors of prognosis of patients assisted with ECMO^[6-8]. However, limited reports focused on patient prognosis analysis assisted with ECMO. This study analyzed the clinical data of patients with heart transplantation applying ECMO in one center to explore its prognosis risk factors.

Materials And Methods

1.1 Patient choice retrospective

Analysis of 28 heart transplantation patients with ECMO was conducted from January 2012 to January 2018 in the People's Hospital of Zhongshan City. Inspection and approval were sought from the ethics committee of the People's Hospital of Zhongshan City. Excluded patients comprised those who are younger than 18 years old. Finally, 25 patients whose ECMO-assisted time was less than 48 h were included in the study.

1.2 ECMO method

ECMO indications consist of the following: patients exhibiting tissue hypoperfusion performance and hypotension and low cardiac output requiring adequate blood volume; appropriate volume management, positive inotropic drugs, and vasoconstriction or intra-aortic balloon pump application for shock still in use; pulmonary hypertension, decreased right heart function, failed medication, and sustained shock in continual progress. The perfusion system comprised a Medtronic Biopump centrifugal pump, Medtronic oxygenator, ECMO set filled with Camedia heparin provided by Medtronic, and whole Medtronic intubate of femoral artery and vein, whose size is determined by the patient's weight, height, and blood vessel thickness. All patients were treated with vein-arterial ECMO (vein-artery ECMO,V-AECMO) mode. Medtronic heparin-coated integral femoral arteriovenous intubate was placed separately through the femoral artery and vein 15 Fr-20 Fr (10–15 cm) and 19 Fr–22 Fr (35–45 cm). The distal extremity of the arterial intubate was placed in a reperfusion catheter, 6 Fr–8 Fr cannula, and connected to the femoral cannula shunt joint.

1.3 Data collection

The general condition of the patient before heart transplantation was collected, with the specific information shown in Table 1. Table 3 shows in detail the condition of patients with heart transplantation. After heart transplantation, ECMO was applied; the specific data are shown in Table 4. Table 2 provides specific information on donor status .

1.4 Statistics Analysis

SPSS2.0 software was adopted in this study, and variance was expressed by the mean $\pm$ standard deviation if the measurement data satisfied normal distribution. The comparison between groups was based on independent sample t test. Otherwise, the median (interquartile range) was used, and independent sample nonparametric rank-sum test was used for comparison between groups. The counting data were expressed as percentages, and chi-square test was used for comparison between groups. The influencing factors of the outcomes of exploration were analyzed by multivariate logistic regression analysis, and a *P* value of <0.05 was considered statistically significant.

Results

2.1 Basic conditions and clinical prognosis of patients

A total of 25 patients (20 male and 5 female) were included in this study. Heart transplantation was performed mainly due to cardiomyopathy (77.8%). Eighteen patients survived and were discharged (72%). Four patients were treated with cardiopulmonary resuscitation before ECMO, and three patients died in the hospital (Table 1).

2.2 Donator status

Table 2 shows the donator status of the two groups for patients. No differences existed in the two donor groups (N-terminal pro b-type natriuretic peptide (NT-proBNP), creatine kinase-muscle/brain (CK-MB), warm ischemia time of donated heart, cold ischemia time of donated heart, total ischemia time of donated heart, and donator type).

2.3 Univariate analysis of ECMO prognosis for patients with heart transplantation

Univariate analysis showed that body mass index (BMI), days of stay in intensive care unit (ICU), and cardiopulmonary resuscitation are relevant prognosis factors in applying ECMO for patients with heart transplantation (Tables 1 and 4).

2.4 Multi-factor logistic regression analysis of ECMO for prognosis of patients with heart transplantation

Multi-factor logistic regression results showed that cardiopulmonary resuscitation before ECMO (odds ratio (OR): 49.45; 95% confidence interval (C.I.): [1.37, 1781.6]; $P=0.033$) is an independent risk factor influencing prognosis (Table 5).

Discussion

ECMO is an important choice for patients with refractory cardiogenic shock and can be used in waiting for heart transplant patients and heart failure after heart transplantation. This study aimed at exploring risk factors affecting the clinical prognosis through analyzing the clinical data of heart transplantation patients with ECMO. The results of this study indicate that ECMO-assisted survival rate of heart transplant patients reaches 72%. Univariate analysis showed that high BMI, high NT-proBNP before operation, substantial erythrocyte infusion, and long period of stay in ICU are prognosis risk factors for patients with heart transplantation. Univariate analysis indicates that CPR before ECMO of a patient is an independent risk factor for prognosis.

The single factors in this study suggest that higher BMI leads to poorer prognosis, which may be related to the inability of obese patients to achieve adequate blood flow. However, the research of SALNA et al. indicated that survival discharge rates of obese patients and morbidly obese patients showed no statistical difference from that of non-obese patients assisted by ECMO. Thus, BMI is not an analysis factor predicting the prognosis of patients in hospitals [9]. Furthermore, research results of Lee et al, who showed the increased death rate of patients with high BMI and assisted by ECMO in 30 days, are the same with those of this research [10]. Hospital-acquired infection is one of the complications of ECMO,

thus increasing postoperative mortality ^[11]. Long-term stay in ICU is the main risk factor for all nosocomial infections [12]. This study demonstrates that long-term stays in ICU are risk factors for the prognosis of heart transplantation patients. The use of postoperative immunosuppressive agents in heart transplant patients may increase the risk of infection in patients.

This study demonstrates that CPR before ECMO prognosis is an independent risk factor for prognosis. Studies have shown that rapid ECMO assist after cardiac arrest is an important factor in reducing neurological complications ^[13], whereas long-term CPR will increase patient mortality ^[14]. Establishing ECMO in a timely manner after cardiac arrest affects the patient's prognosis ^[15]. Therefore, the reasons for the results of this study may include the following: 1. The quality of cardiopulmonary resuscitation and inadequate extracardiac and untimely compression, which lead to insufficient infusion of tissue and organs, result in hypoxia and necrosis of tissue and organs and ultimately affect prognosis. Lactic acid is an important indicator of metabolism. Studies have shown that hyperlactosis is an independent risk factor affecting the prognosis of patients ^[16]. 2. Critical patient condition is and poor general condition. In this study, patients with heart transplantation included those with valvular disease, cardiomyopathy, or coronary heart disease, featuring poor heart function. Decreased cardiac reserve can easily lead to heart failure and final cardiac arrest. These patients may suffer from impaired function of tissues and organs, such as liver and kidney. The occurrence of cardiac arrest further impairs their function. The sustained hyperbilirubin affects the prognosis of patients ^[17].

This study features limitations: 1. The study is a single-center retrospective study; 2. the study sample size is small; 3. variables such as complications are unaffected by factors such as small sample size. A multi-center joint study will be conducted in the future to expand the sample size and analytical variables.

Conclusion

ECMO is an important life support method for patients with heart transplantation before and after the operation. Patients with obesity, poor preoperative cardiac function, and sizeable red blood cell transfusions during surgery may influence the prognosis of patients. Extracardiac compression before ECMO of the patients is an independent risk factor for the prognosis of patients.

List Of Abbreviations

Extracorporeal membrane oxygenation :ECMO;

terminal pro b-type natriuretic peptide :NT-proBNP;

Creatine kinase-muscle/brain :CK-MB;

Declarations

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Retrospective data collection was approved by the Institutional Review Board at Zhongshan hospital affiliated to Sun Yat-Sen University.

CONSENT FOR PUBLICATION

WRITTEN INFORMED CONSENT FOR PUBLICATION WAS OBTAINED FROM ALL PARTICIPANTS

AVAILABILITY OF DATA AND MATERIAL

ALL DATA GENERATED OR ANALYSED DURING THIS STUDY ARE INCLUDED IN THIS PUBLISHED ARTICLE

COMPETING INTERESTS

NO CONFLICT OF INTEREST EXISTS IN THE SUBMISSION OF THIS MANUSCRIPT.

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Xiaozu Liao ✉ *DRAFTING ARTICLE*

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Tables

Table 1 General conditions before heart transplantation in two groups of patients

Variable	Grouping	Discharge (18)	Death (7)	chi- square/t value	P value
Gender	Male	14 (77.8%)	6 (85.7%)	0.198	0.656
	Female	4 (22.2%)	1 (14.3%)		
Age		42.44±14.09	46.86±17.83	-0.654	0.520
BMI		19.67±4.64	25.71±9.39	-2.172	0.040
ABO blood group	A	4 (22.2%)	1 (14.3%)	0.289	0.866
	B	6 (33.3%)	3 (42.9%)		
	O	8 (44.4%)	3 (42.9%)		
Smoking	Non-smoking	14 (77.8%)	7 (100.0%)	1.852	0.174
	Smoking	4 (22.2%)	0 (0.0%)		
Etiological diagnosis	Valvular disease	3 (16.7%)	2 (28.6%)	0.773	0.680
	Coronary heart disease	1 (5.6%)	0 (0.0%)		
	Myocardiopathy	14 (77.8%)	5 (71.4%)		
Heart function classification	III	5 (27.8%)	1 (14.3%)	0.503	0.478
	IV	13 (72.2%)	6 (85.7%)		
Diabetes mellitus	No	17 (94.4%)	5 (71.4%)	2.528	0.112
	Yes	1 (5.6%)	2 (28.6%)		
CPR before ECMO	No	17 (94.4%)	4 (57.1%)	5.218	0.022
	Yes	1 (5.6%)	3 (42.9%)		
Active drugs for vein vascular application	No	12 (66.7%)	3 (42.9%)	1.190	0.275
	Yes	6 (33.3%)	4 (57.1%)		
ECMO applied before operation	No	16 (88.9%)	4 (57.1%)	3.175	0.075
	Yes	2 (11.1%)	3 (42.9%)		
Preoperation creatinine		102.09±60.77	119.86±59.42	-0.660	0.516
Preoperation glutamic- oxaloacetic transaminase AST		27.00 (16.00, 50.75)	67.00 (12.00, 166.00)	-0.576	0.565

Preoperation ALT	24.00 (16.75, 47.75)	77.00 (21.00, 86.00)	-1.241	0.215
Preoperation bilirubin	25.10 (17.35, 34.85)	32.90 (24.20, 89.00)	-1.513	0.130
Preoperation NT-proBNP	114.50 (89.00, 163.75)	754.10 (120.00, 8900.00)	-2.064	0.039
Left ventricular ejection fraction	31.50±17.98	30.57±16.97	0.118	0.907
Estimated pulmonary systolic pressure	56.39±18.38	56.13±17.65	0.033	0.974

cardiopulmonary resuscitation:CPR

Table 2 Donor status of two groups of patients

Variable	Grouping	discharge	death	chi-square/t value	P value
NT-proBNP		86.72±32.34	77.29±15.00	0.735	0.470
CK-MB		16.56±9.75	13.00±3.16	0.935	0.360
Warm ischemia time		3.67±1.14	3.57±0.79	0.202	0.842
Cold ischemia time		176.67±94.53	163.29±55.97	0.349	0.730
Total ischemia time		180.33±94.54	167.29±55.88	0.340	0.737
Donor type	cerebral death	13(72.2%)	5(71.4%)	0.002	0.968
	Total	5(27.8%)	2(28.6%)		

Table 3 Conditions during heart transplantation operation in two groups of patients

Variable	Grouping	discharge	death	chi-square/t value	P value
Extracorporeal circulation time		187.06±70.56	229.71±52.49	-1.444	0.162
Clamping time of ascending aorta		106.00±42.31	133.86±34.58	-1.547	0.136
Erythrocyte		200.00 (0.00, 850.00)	1200.00 (800.00, 1400.00)	-2.260	0.024
Plasma		600.00 (0.00, 800.00)	800.00 (500.00, 1200.00)	-1.425	0.154
Platelet		0.00 (0.00, 62.50)	250.00 (0.00, 500.00)	-1.617	0.106

Table 4 Application of ECMO in two groups of patients after operation

Variable	Grouping	discharge	death	chi-square/t value	P value
Days stayed in ICU		8.00 (6.00, 11.75)	19.00 (15.00, 23.00)	-3.006	0.003
Total time of mechanical ventilation		56.50 (25.75, 184.00)	240.00 (25.00, 480.00)	-1.182	0.237
Total application time of ECMO		106.00 (83.00, 133.50)	120.00 (72.00, 230.00)	-0.182	0.856
Postoperation input of packed erythrocyte		1300.00 (0.00, 3750.00)	4000.00 (0.00, 8000.00)	-0.801	0.423
Postoperation input of plasma		1400.00 (0.00, 4825.00)	3000.00 (0.00, 4000.00)	-0.344	0.731
Postoperation input of platelet concentrates		135.00 (0.00, 762.50)	500.00 (0.00, 500.00)	-0.501	0.616
Multiple cardiopulmonary bypass	No	18 (100.0%)	6 (85.7%)	2.679	0.102
	Yes	0 (0.0%)	1 (14.3%)		
Secondary chest open	No	9 (50.0%)	2 (28.6%)	0.939	0.332
	Yes	9 (50.0%)	5 (71.4%)		
Infection site	Pulmonary infection	9 (50.0%)	5 (71.4%)	0.939	0.332
	No	9 (50.0%)	2 (28.6%)		

Table 5: Multivariate logistic regression analysis results

Variable	B	S.E.	Wals	P value	OR value	95% of OR value C.I.	
						lower limit	upper limit
BMI	0.333	0.172	3.760	0.053	1.396	0.996	1.955
Days stayed in ICU	0.151	0.084	3.279	0.070	1.163	0.988	1.370
CPR before ECMO	3.901	1.829	4.551	0.033	49.458	1.373	1781.663