Archives of Clinical and Experimental Surgery, 2023
VOL 12, NO.09, PAGE 01-05

RESEARCH ARTICALE

Open Access

Effect of ECMO on Heart Failure after Cardiac Surgery

Han Wanlei, Zhing Yeing*

Department of Cardiac Surgery, Southeast University, Jiangsu, China

ABSTRACT

Objective: To summarize the clinical data of 11 patients subjected to Extra Corporeal Membrane Oxygenation (ECMO) after cardiac surgery and to analyze the auxiliary effect of ECMO and related risk factors.

Study design: Evidence based reports.

Place and duration of study: From January 2020 to March 2022.

Methods: The clinical data of 11 patients who received ECMO support after cardiac surgery in our hospital were collected. The corresponding risk factors were obtained through statistical analysis and the effect of ECMO support was evaluated.

Results: Statistical analysis indicated that the preoperative Ejection Fraction (EF) ≤ 45% and postoperative lactic acid ≥ 10 mmol/L were statistically different between the groups (P=0.002).

Conclusion: Preoperative EF ≤ 45% and postoperative lactic acid ≥ 10 mmol/L are independent risk factors for the prognosis of ECMO after cardiac surgery. The present findings indicated that ECMO support improves the survival rate.

ARTICLE HISTORY
Received: 19-Sep-2023, Manuscript No. EJMACES-23-114247; Editor assigned: 21-Sep-2023, PreQC No. EJMACES-23-114247 (PQ); Reviewed: 06-Oct-2023, QC No. EJMACES-23-114247; Revised: 13-Oct-2023, Manuscript No. EJMACES-23-114247 (R); Published: 20-Oct-2023

Keywords
ECMO; Heart failure; Cardiac surgery; Artery

Introduction

After cardiac surgery intervention, approximately 3%-8% of patients have cardiac dysfunction or low cardiac output syndrome [1]. Patients usually require a large number of positive inotropic drugs, vasopressors and even mechanically assisted circulation, such as aortic balloon counterpulsation [2]. However, Intra-Aortic Balloon Pump (IABP) alone is not sufficient to maintain stable circulation due to severe cardiac and/or pulmonary dysfunction and other mechanical circulatory support treatment may be required. Extra Corporeal Membrane Oxygenation (ECMO) is mainly used to provide continuous extracorporeal respiration and circulation for patients with severe cardiopulmonary failure to maintain the patient's life. ECMO support has a good effect in many patients with low cardiac output syndrome, such as poor cardiac function after cardiac incision [1,3]. Previously identified prognostic factors include prevention of left ventricular overload, pulmonary edema, lung injury and myocardial injury. Other prognostic indicators are low oxygen partial pressure, low oxygen saturation, advanced age, preoperative complications, type of surgical procedure and high blood product requirements [4]. From January 2020 to March 2022, we collected the clinical data of 11 patients with heart failure requiring ECMO support after open heart surgery in the Department of Cardiac Surgery of Shanxi Cardiovascular Hospital. Statistical analysis identified the independent risk factors for the survival of such patients in our center and provided some clinical treatment experience for future work.

Material and Methods

ECMO was established in five patients through peripheral intubation, Venous-Arterial (VA) mode by incision of the femoral artery and femoral vein under direct vision with the following bypass route; femoral vein-centrifugal pump-artificial membrane lung-femoral artery. To avoid ischemic necrosis of the ipsilateral lower limb, a perfusion tube was placed in the ipsilateral superficial femoral artery to connect the branches of ECMO arteries to provide blood supply to the distal limb. ECMO, VA mode was established in six patients through central catheterization of the ascending aorta and right atrium intubation with the following bypass route: Right atrium-centrifugal pump-artificial membrane lung-ascending aorta. To reduce left heart load, a left heart drainage tube was placed through the right upper pulmonary vein.

Contact: Zhyng Yeng, E-mail: yzhyng46@qq.com

Inclusion criteria

Patients who received ECMO after cardiac surgery in our hospital between January 2020 and March 2022.

Exclusion criteria

Patients who had used ECMO support before surgery or the surgery was performed with ECMO support.

SPSS 21.0 was used for statistical analysis of the data. Statistical description of the adoption rate or composition ratio of counting data. Shapiro-Wilk test was used to judge the normality of the measurement data. The mean ± standard deviation statistical description was used for the measurement data meeting the normal distribution, and the t test of two independent samples was used for statistical analysis. For measurement data that did not meet the normal distribution, median (first percentile, third percentile) was used for statistical description and Wilcoxon rank sum test was used for statistical analysis. All variables with significant differences (P<0.05) were included in the logistic regression analysis model for multivariate analysis. P<0.05 indicated that the difference was statistically significant.

Results

The present study summarized the data of 11 patients who required ECMO assistance after cardiac surgery, in which 4 patients survived and 7 patients died. The survival rate was 36.4%. Among the 11 ECMO-assisted patients, preoperative cardiac function ≤ 45% (P=0.002) and postoperative lactic acid >10 mmol/L (p=0.002) are independent risk factors for such patients. The detailed statistical analysis results are shown in Tables 1-3.

Table 1. General clinical data.

General data	Case	Percentage (%)
Gender		
Males	7	63.6
Females	4	36.4
Operation		
Valve replacement	5	45.5
CABG	4	36.4
CABG+ valve replacement	1	9.1
Aortic surgery	1	9.1
Preoperative cardiac function classification (NYHA)		
II	7	63.6
III	4	36.4
ECMO		
Intraoperative	10	90.9
Postoperative	1	9.1
Intubation method		
Central	6	54.5
Periphery	5	45.5
IABP		
Yes	9	81.8
No	2	18.2
Prognosis		
Survival	4	36.4
Death	7	63.6
Note: CABG: Coronary Artery Bypass Grafting; NYHA: New York Heart Association; ECMO: Extra Corporeal Membrane Oxygenation; IABP: Intra-Aortic Balloon Pump.		

Table 2. Single-factor statistical analysis results.

Parameter	Survival (4case)	Death (7case)	t	P-value (t-test)
Age	61.5 ± 2.65	63.71 ± 4.61	0.87	0.407
Weight (kg)	70.75 ± 8.3	66.93 ± 17.07	0.414	0.689
Preoperative EF (%)	64.50 ± 4.43	31.14 ± 2.41	16.48	<0.001
CPB time (min)	368.5 ± 151.32	437.71 ± 290.34	0.437	0.672
ACC time (min)	190.75 ± 124.89	176 ± 140.26	0.174	0.866
LV (mm)	48.00 ± 5.48	53.00 ± 8.51	1.045	0.323
ECMO assistant time (h)	72.0 (24.0,132.0)	165.0 (65.0,187.0)	1.134	0.257
Respirator assistant time (h)	271 ± 225.33	219.14 ± 176.66	0.426	0.68
Postoperative red blood cell dosage (u)	7.5 ± 7.55	17.43 ± 11.7	1.508	0.166
Postoperative plasma dosage (ml)	1450 ± 680.69	2671.43 ± 2059.7	1.128	0.288
Postoperative platelet dosage (U)	2.33 ± 1.53	4.57 ± 4.16	0.881	0.404
Postoperative lactic acid	9.28 ± 0.56	22.43 ± 2.82	16.323	<0.001
Lactic acid 24 h after surgery	1.63 ± 0.22	6.02 ± 4.24	2.532	0.077
Postoperative transaminase (mmol/L)	125.5 (77.15,383.18)	225 (92.90,264.30)	0.567	0.571
Postoperative creatinine (mmol/L)	124.45 (96.68,167.23)	117.60 (108.40,478.00)	0.189	0.85
Postoperative EF (%)	39.75 ± 13.30	25.43 ± 5.16	2.066	0.028
Postoperative BNP	4893.50 (921.75,12751.75)	15000 (4225.00,24687.00)	1.323	0.23
Note: EF: Ejection Fraction; CPB: Cardio Pulmonary Bypass; LV: Left Ventricular; ECMO: Extra Corporeal Membrane Oxygenation.				

Table 3. Logistic regression analysis results.

Parameter	P-value
Preoperative EF ≤ 45%	0.002
Postoperative lactic acid ≥ 10 mmol/L	0.002
Note: EF: Ejection Fraction.	

Discussion

Low cardiac output syndrome is one of the main causes of early death in patients after cardiac surgery. Most patients with low cardiac output syndrome recover after drug treatment and IABP. However, some patients with low cardiac output syndrome do not recover after drug treatment and IABP alone and they need ECMO support to gain time, allowing for potential cardiopulmonary function recovery [5,6]. In general, the main manifestation of cardiac surgery is poor cardiac function, which is mainly treated with application of Venous Arterial (VA mode) assistance. Assisted posterior circulation state and oxygenation state can achieve satisfactory results, which allow cardiopulmonary bypass to be stopped, allowing time for the survival of patients. The present study summarized the data of 11 patients who required ECMO assistance after cardiac surgery, in which 4 patients survived and 7 patients died. The survival rate was 36.4%, which was slightly lower than that reported by other centers at home and abroad (40%-60%). Statistical analysis indicated that preoperative cardiac function Left Ventricular Ejection Fraction (LVEF) ≤ 45% and postoperative lactic acid ≥ 10 mmol/L were independent risk factors for death after ECMO-assisted cardiac surgery.

Poor preoperative cardiac function often indicates poor prognosis after surgery, especially in patients

with preoperative EF ≤ 45% and cardiac surgery itself has a certain trauma, which has impacts cardiac function. The incidence of cardiac dysfunction in patients after cardiac surgery is 3%–5%, of which approximately 1% of patients need ECMO assistance. Although the early circulatory state and oxygenation state can be improved to a certain extent, such patients often need assistance for a long time and the recovery of cardiac function cannot be restored after a slow recovery, during which pulmonary infection, acute liver failure, acute renal failure and other serious complications may occur, eventually leading to irreversible multiple organ failure and death.

Postoperative lactic acid level often indicates the prognosis of surgery. Blood lactic acid index is an important indicator of tissue perfusion and lactic acid ≥ 10 mmol/L or continuous increase of lactic acid often indicates poor prognosis [7,8]. Similarly, a previous report studying patients who return to the ICU for blood gas analysis after surgery has found that patients with lactic acid greater than 10 mmol/L do not survive, while patients with lactic acid less than 10 mmol/L survive. Although the lactic acid in the higher lactic acid group is reduced to less than 10 mmol/L within 24 h after surgery, the results cannot be reversed. Considering that severe circulatory disorders have caused great damage to many organs, this damage may be irreversible. Although early intervention treatment has been actively carried out, the outcome cannot be reversed. At the same time, such patients often have poor cardiac function, indicating that ECMO support cannot be removed quickly and the accompanying complications increase, eventually leading to death.

The application of ECMO support for low cardiac output syndrome after cardiac surgery is an effective transition method. The treatment effect is worthy of recognition, but there are many details to be considered to attain satisfactory results, such as timing of the machine, management during the auxiliary period, maintenance of various organ functions and timing of weaning.

The timing of the machine should be sooner rather than later, especially for patients with poor preoperative cardiac function. Therefore, appropriate relaxation of ECMO indications at some moments may help to save patients with low cardiac output syndrome after cardiac surgery.

The management during ECMO support, such as respiratory support is also particularly important. In general, patients after cardiac surgery need respirator support during ECMO assistance and the time of tracheal intubation is long. Some studies have reported that low tidal volume (4 ml/kg) avoids lung injury caused by excessive airway pressure, low oxygen concentration (30%-40%) avoids high oxygen damage and low frequency (6-8 times/min) and high PEEP ventilator support (8-10 cm H_2O) maintain normal alveolar function and avoid collapse [9]. Acute kidney injury, with a high incidence rate of 81%, is also one of the common complications after ECMO assistance and acute kidney injury also greatly affects the prognosis of ECMO-assisted patients. In the present study, 3 of the 11 patients had acute kidney injury after operation and were treated with Continuous Renal Replacement Therapy (CRRT), but they did not survive. Because the present study had a small sample size, the statistics for acute kidney injury were meaningless. Postoperative acute renal injury may also be a major risk factor that significantly increases the mortality during ECMO support after cardiac surgery [10]. It has been reported that early CRRT reduces renal load, corrects renal function damage, maintains volume balance, filters out inflammatory factors and improves prognosis, thereby improving patient survival [11]. For patients with postoperative acute kidney injury, CRRT should not be dependent on increases in creatinine levels, decreases in urine volume, or balance of capacity. This study was limited by a small sample size. Considering the limitations in this study, some recommendations are proposed here for future improvements. It was a retrospective study, and thus the lack of randomized studies resulted in selection bias. It is suggested to merge more data on patient characteristics and treatment algorithms. Secondly, this study tended to summarize patients with the surgery treatment, while the results may not necessarily apply to patients who received bridging with a ventricular assist device. In addition, long-term follow-up precludes is highly recommended to assess treatment effects persistently.

Conclusion

The use of ECMO support in patients with heart failure after cardiac surgery improves their survival rate. Preoperative cardiac function ≤ 45% and postoperative lactic acid>10 mmol/L are independent risk factors for such patients. The adjustment of preoperative cardiac function and the management of intraoperative acid-base balance improves the success rate of ECMO-assisted survival, but it is necessary to start ECMO support as soon as possible. Moreover, strict management during ECMO assistance reduces the occurrence of complications and greatly improves the success rate of ECMO assistance.

References

[1] Baran DA. Extra Corporeal Membrane Oxygenation (ECMO) and the critical cardiac patient. Curr Transplant Rep 2017;4(3):218-225.

[2] Hajiyev V, Erkenov T, Smechowski A, Soeren J, Fritzsche D. Follow-up on ECMO after cardiac surgery: How can we evaluate therapy? Heart Surg Forum 2019;22(1): E011-E014.

[3] Stub D, Bernard S, Pellegrino V, Smith K, Walker T, Sheldrake J, et al. Refractory cardiac arrest treated with mechanical CPR, hypothermia, ECMO and early reperfusion (the CHEER trial). Resuscitation 2015;86:88-94.

[4] García-Carreño J, Sousa-Casasnovas I, Devesa-Cordero C, Gutiérrez-Ibañes E, Fernández-Avilés F, Martínez-Sellés M, et al. Cardiopulmonary resuscitation with percutaneous ECMO in refractory in-hospital cardiac arrest: A single-center experience. Rev Esp Cardiol (Engl Ed) 2019;72(10):880-882.

[5] Beiras-Fernandez A, Deutsch MA, Kainzinger S, Kaczmarek I, Sodian R, Ueberfuhr P, et al. Extracorporeal membrane oxygenation in 108 patients with low cardiac output-a single-center experience. Int J Artif Organs 2011;34(4):365-373.

[6] Odonkor PN, Stansbury L, Garcia JP, Rock P, Deshpande SP, Grigore AM, et al. Perioperative management of adult surgical patients on extracorporeal membrane oxygenation support. J Cardiothorac Vasc Anesth 2013;27(2):329-344.

[7] Chen YS, Yu HY, Huang SC, Lin JW, Chi NH, Wang CH, et al. Extracorporeal membrane oxygenation support can extend the duration of cardiopulmonary resuscitation. Crit Care Med 2008;36(9):2529-2535.

[8] Park SJ, Kim SP, Kim JB, Jung SH, Choo SJ, Chung CH, et al. Blood lactate level during extracorporeal life support as a surrogate marker for survival. J Thorac Cardiovasc Surg 2014;148(2):714-720.

[9] Lu AD, Dong SQ. Clinical application of extracorporeal membrane oxygenation support after cardiac surgery. Chinese J Extracorporeal Circulation 2017;15(2):100-104.

[10] Luckraz H, Gravenor MB, George R, Taylor S, Williams A, Ashraf S, et al. Long and short-term outcomes in patients requiring continuous renal replacement therapy post cardiopulmonary bypass. Eur J Cardiothorac Surg 2005;27(5):906-909.

[11] Schmidt M, Bailey M, Kelly J, Hodgson C, Cooper DJ, Scheinkestel C, et al. Impact of fluid balance on outcome of adult patients treated with extracorporeal membrane oxygenation. Intensive Care Med 2014;40:1256-1266.