Rescue ECMO in Infant with Congenital Heart Disease: Early Experience at a University Hospitals

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ABSTRACT

Background: Extracorporeal membrane oxygenator (ECMO) is one of challenging mechanical support devices that can increase a chance of survival in infant patients who undergo complicated congenital cardiac surgery, but cannot be separated from cardiopulmonary bypass. ECMO also rescues cardiac arrest patients after cardiac intervention or from other reasons. We would like to show our outcome in early experience.
Methods: We retrospectively reviewed our medical records of all infant patients supported with ECMO after they underwent cardiac procedures between January 2011 and December 2013. Their demographic data, diagnosis, procedure variables, ECMO indication and duration, blood product administration, circuit-related complication, ICU length of stay, intubation period time, and perioperative outcome were analyzed.
Results: There were six patients (Male = 5, Female = 1) with congenital heart disease who received ECMO following cardiac intervention (n=2) or cardiac surgery (n=4). Four patients with post-cardiac surgery had a mean cardiopulmonary bypass time of 347.25 minutes (SD= 132.10, range 235-530 minutes) and a mean aortic cross-clamp time of 90.75minutes (SD=47.74, range 52-159 minutes). The median age of ECMO induction was 32 days (range 1-182 days) and the mean weight of patients at ECMO induction was 3.15 kg (SD=0.67, range 2.5-4.3 kg). All patients received venoarterial type of ECMO support. The reasons for rescue ECMO were post-cardiac arrest (n=1), inability to wean from cardiopulmonary bypass (n=3), pulmonary hypertension (n=1), and cardiogenic shock (n=1). Five of them were successfully weaned from ECMO. Overall Survival in this group was 50% (3 out of 6 patients). Sepsis, cardiomyopathy and pulmonary hypertension were causes of death.
Conclusion: ECMO is an efficacious method for rescuing some infant patients who undergo complex congenital heart surgery or cardiac intervention with critical unstable status or post-cardiac arrest.

Keywords: ECMO, congenital heart disease, infant

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INTRODUCTION

Congenital heart disease (CHD) is one of the most common problems in infants. The incidence is found in the birth rate of 5-8 cases per 1,000 live-births. About 25% of infants with a CHD have a critical CHD. Generally they need surgery or other procedures in their early phase of life. The first application of ECMO supporting palliative cardiac surgery in infants was reported in 1970.[1] Nowadays, we can do more complicated cardiac surgery in small infant patients. Some patients need ECMO after surgery according to low cardiac output that we cannot wean off bypass or some infants after cardiac

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intervention, also need ECMO support due to unstable hemodynamics.[2] The registry of the extra-corporeal life support organization (ELSO) had reported the overall survival of cardiac ECLS in infants was 43% (3,804 of the total 8,946).[3] In our center, between 2011 and 2013, 935 congenital heart operations were performed and 218 patients (23%) were under one year of age. There are many indications for infant cardiac ECMO such as cardiogenic shock, inability to wean from CPB, pulmonary hypertension and post cardiac arrest.[4,5]

MATERIALS AND METHODS

We retrospectively reviewed medical records of all patients with aging under one year old who received congenital heart operations from January 2011 to December 2013. The inclusion criteria were infants, the gestational age of patient was more than 34 weeks or body weight at ECMO induction was more than 2 kg and the patients were indicated for ECMO. Each patient record was analyzed for their demographic data, diagnosis, procedure variables, ECMO indication and duration, circuit-related complication, ICU length of stay period time, and perioperative outcome.

In ECMO technique, venoarterial ECMO or VA-ECMO was used in all the patients. Almost all of the patients had central cannulation for the ECMO device. We used a centrifugal pump Cen-triMag® and used a membrane oxygenator of EUROSETS (Medolla, MO, Italy) oxygenator. The initial ECMO flow rate was set at 150-180 ml/kg/min. The Heparin infusion was started at 100 unit/kg and titrated to maintain an activated clotting time of 180-220 seconds. The hematocrit was maintained above 40% by transfusion of packed red cells. The sternum was retained open and the wound covered by silastic membrane. After a patient has been on ECMO for 24-48 hours with cardiovascular and pulmonary recovery, we decided to wean off ECMO by decreasing ECMO flow 10% every 1-2 hours. We performed echocardiography and arterial blood gas for guiding ECMO weaning and decannulation.

The objective of this study was to evaluate the feasibility and efficacy of ECMO in our early experience, the primary outcome was survival to discharge rate and the secondary outcome was success rate of ECMO decannulation.

This study was reviewed and given ethical approval by Siriraj Institutional Review Board for Human Research as per the Declaration of Helsinki, ICH-GCP, and CIOMS guidelines.

TABLE 1. Demographic data.

Case	Gender	Age (day)	BW (kg)	Diagnosis	Procedure	Indication
1	Male	17	3.1	PA/IVS, PDA	BAS	Post cardiac arrest
2	Male	13	2.5	D-TGA/IVS, Abnormal coronary a. s/p BAS	Total correction	Inability to wean from CPB
3	Female	182	3.6	TA type1, Pulmonary hypertension	Total repair	Pulmonary hypertension
4	Male	47	4.3	ALCAPA, LV dysfunction	LMCA implant to ascending aorta	Inability to wean from CPB
5	Male	1	3.2	Fetal bradycardia	PPM	Cardiogenic shock
6	Male	65	2.6	IAA type B, VSD (subaortic), PDA	Total repair	Inability to wean from CPB

PA/IVS = pulmonary atresia with intact ventricular septum, PDA = patent ductus arteriosus, BAS = balloon atrial septostomy,
D-TGA/IVS = D-transposition of the great arteries with intact ventricular septum, TA type1 = truncus arteriosus type1, ALCAPA = anomalous left coronary artery origin from the pulmonary artery, LV = left ventricular, LMCA = left main coronary artery, PPM = permanent pacemaker, IAA type B = interrupted aortic arch type B, VSD = ventricular septal defect, CPB = cardiopulmonary bypass

TABLE 2. ECMO data.

Case	ECMO Duration (day)	Decannulation	Results
1	5.54	Success	Death
2	5.75	Fail	Death
3	1.36	Success	Death
4	2.54	Success	Survive
5	4.58	Success	Survive
6	2.70	Success	Survive

All descriptive analysis was performed using SPSS statistical software version 20.0. Data were expressed as mean ± standard deviation or median with range. Fisher's exact tests or chi-square analyses were used to assess categorical comparisons between survived ECMO and died on ECMO groups. A p-value < 0.05 was considered statistically significant.

RESULTS

A total of six infant patients with congenital heart disease underwent cardiac ECMO (Table 1). Five males and one female received ECMO following cardiac procedure in 2 patients, and cardiac surgery in 4 patients. The median age of ECMO induction was 48 days, and the mean weight of patients at ECMO induction was 3.2 kg. For the indications of our patients these were due to inability to wean from cardiopulmonary bypass, post-cardiac arrest, pulmonary hypertension, and cardiogenic shock. The patients with post-cardiac surgery had a mean cardiopulmonary bypass time of 231.5 minutes and a mean aortic cross-clamp time of 60.5 minutes.

The characteristics of ECMO support have been shown (Table 2). The median of ECMO duration was 5.1 days. Five out of 6 patients (83%) were able to wean off ECMO and the overall survival in this group was 3 out of 6 patients (50%). Causes of death were sepsis, cardiomyopathy, and pulmonary hypertension. This study found various complications from ECMO and the major complication were bleeding, acute renal failure and infection.[6] According to the risk factors there was no statistical significance among survived ECMO group and died on ECMO group[7] (Table 3).

DISCUSSION

The data of cardiac ECMO has been reviewed from other centers around the world[8-12] (Table 4). The rate of wean off ECMO varies, but the survival of ECMO is about 40%. Our center has used the cardiac infant ECMO for 3 years and the results showed overall survival of 50%, which are a better result when compared to the others. However this is a case series, so we need more sample size for determining the factors that have effect to the morbidity and mortality of infant patients with critical congenital heart disease who need ECMO support after cardiac surgery or intervention.

Another type of ECMO is VV-ECMO or venovenous ECMO. VV-ECMO also has been used in non-cardiac patients with severe reversible diseases such as congenital diaphragmatic hernia with lung hypoplasia, hyaline membrane disease, ARDS, meconium plug syndrome, etcetera, in other international centers, until pulmonary

TABLE 3. Risk factors data.

Variables	Survived ECMO	Died on ECMO	P-value
Age (day)	47(1-65)	17(13-182)	1.00
BW (kg)	3.37±0.86	3.07±0.55	0.64
Gender (Male/Female)	3/0	2/1	1.00
Arterial Blood Gas pH	7.36±0.08	7.21±0.40	0.57
Hematocrit level	41.67±4.51	31.27±6.54	0.09
ECMO duration (day)	3.27±1.13	4.21±2.48	0.58
Renal failure (Yes/No)	0/3	2/3	0.40

TABLE 4. Comparison data.

Places of center	Year	Numbers of patients	Percentages of decannulation	Percentages of survive
New Delhi	11 (2000-2010)	94	23	54
Washington	6 (2003-2008)	58	67	41
Kanagawa	9 (2003-2011)	35	58	47
Okayama	6 (2005-2010)	45	75	57
Turkey	4 (2009-2012)	13	31	15
ELSO		8,946	-	43
Our Study	3 (2011-2013)	6	83	50

function recovers. These will take a longer period of time for ECMO support than VA-ECMO in cardiac conditions. We do not have any experience about VV-ECMO in infant patients at our hospital, but we will in the future.

CONCLUSION

ECMO is an efficacious method for rescuing some infant patients who undergo complex congenital heart surgery or cardiac intervention with critical unstable status, or post cardiac arrest.

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