Original Article

Survival to Hospital Discharge Rate and Factors Affecting Survival Rate of Adult Patients Under Venoarterial Extracorporeal Membrane Oxygenation (VA ECMO) Treatment in King Chulalongkorn Memorial Hospital

Kanin Jantraprapavech MD[1,2], Chayatat Sirinawin MD[2,3], Suphot Srimahachota MD, MSc[1,2]

[1] Division of Cardiology, Department of Medicine, Faculty of Medicine, Chulalongkorn University, Bangkok, Thailand

[2] King Chulalongkorn Memorial Hospital, Thai Red Cross Society, Bangkok, Thailand

[3] Division of Cardiothoracic Surgery, Department of Surgery, Faculty of Medicine, Chulalongkorn University, Bangkok, Thailand

Background: Nowadays, venoarterial extracorporeal membrane oxygenation (VA ECMO) is more acceptable to patients with refractory cardiogenic shock. The number of patients receiving VA ECMO treatment is increasing. However, mortality rate of patients cannulating VA ECMO is still high. Furthermore, VA ECMO treatment is expensive, requiring lots of resources and having lots of limitations. As a result, choosing patient wisely for cannulated VA ECMO is important. This is especially true for treatment in developing countries.

Objective: To find the survival rate of patients receiving VA ECMO treatment and factors that affected survival rate.

Materials and Methods: The present study was a retrospective study using the electronic medical database. Patients with cannulated VA ECMO between 2012 and 2019 were included in the study. Analyses were based on univariate and multivariate logistic regression to find factors associated with survival.

Results: The authors found that out of 81 patients included in the present study, there were 20 survivors, representing a survival rate of 24.69%. Based on Univariate Analysis, factors measured at baseline that affected the survival rate were higher Glasgow Coma Scale, lower arterial blood gas carbon dioxide (ABG $PaCO_2$), lower blood level of lactate before cannulating VA ECMO, lower APACHE II, lower SOFA scores, and predicted mortality rate by SOFA score. Using multivariate regression, the ABG $PaCO_2$ and blood lactate level were significant factors that can predict survival rate (odd ratio 0.91, 95% CI 0.85 to 0.98 and 0.90, 95% CI 0.81 to 0.99, respectively).

Conclusion: The present study found the survival rate of patients cannulating VA ECMO was 24.69%. The lower value of ABG $PaCO_2$ and lactate are significant factors that lead to higher survival rate. These findings lead to recommendations that, for an effective VA ECMO treatment, patients should not be at a severe sickness state, whose ABG $PaCO_2$ and lactate level should be at low levels.

Keywords: Venoarterial extracorporeal membrane oxygenation (VA ECMO); Cardiogenic shock; In hospital survival rate; Factors affecting survival rate

Received 14 September 2020 | Revised 10 November 2020 | Accepted 14 November 2020

J Med Assoc Thai 2021;104(7):1073-81

Website: http://www.jmatonline.com

Venoarterial Extracorporeal Membrane Oxygenation (VA ECMO) is a type of mechanical cardiopulmonary support. Nowadays, it is increasingly used to prevent patients with refractory cardiogenic shock from death. VA ECMO cannulated during cardiopulmonary resuscitation (CPR) is called ECMO CPR (ECPR). ECPR is considered as a better method to improve survival and neurological outcome over conventional CPR (CCPR)[1,2]. VA ECMO is also used in post cardiotomy syndrome[3]. However, the mortality rate of patients cannulating VA ECMO is still high. The survival rate is around 27% to 60%[4-6]. This is because complications may occur during on VA ECMO, such as renal failure, bleeding, and infection[7]. In addition, the treatment expense by VA ECMO is high, and requires lots of resources. The cost is estimated to be around 145,580 USD per one patient[8]. As a result, it is essential to consider the possibility of the patient survival before adopting VA ECMO treatment. This is especially the case for developing countries.

For Thailand, the authors have used VA ECMO

Correspondence to:

Srimahachota S.

Division of Cardiovascular Medicine, Department of Medicine, King Chulalongkorn Memorial Hospital, Bangkok 10330, Thailand.

Phone & **Fax**: +66-2-2564291

Email: s_srimahachota@yahoo.co.th

How to cite this article:

Jantraprapavech K, Sirinawin C, Srimahachota S. Survival to Hospital Discharge Rate and Factors Affecting Survival Rate of Adult Patients Under Venoarterial Extracorporeal Membrane Oxygenation (VA ECMO) Treatment in King Chulalongkorn Memorial Hospital. J Med Assoc Thai 2021;104:1073-81.

doi.org/10.35755/jmedassocthai.2021.07.11929

treatment for patients for more than a decade. However, studies related to VA ECMO are rare. The present study was based on VA ECMO cases in Thailand. The authors investigated the issues of complications, expenses of cannulating VA ECMO, and mortality rate, and tried to identify the factors that have impacts on in-hospital survival.

Materials and Methods

The present study was a single center, retrospective study based on patient cases in King Chulalongkorn Memorial Hospital (KCMH), one of the largest centers of providing VA ECMO treatments for patients in Thailand. The present study was reviewed and approved by the Institutional Review Board of KCMH (IRB No. 399/62), and consent was waived. There was no sponsor. Data were collected from patient electronic medical records.

Patients who cannulated VA ECMO in KCMH between January 1, 2012 and July 1, 2019, age older than 15 years and with complete primary information were included in the present study. After data screening, 81 were patients included. Collected data were categorized into two groups in accordance with the states of survival outcomes, namely survival group and non-survival group. Then, statistical analyses were processed to find factors that affected the outcomes of survival.

The general criteria for accepting a patient to have VA ECMO treatment in KCMH are refractory cardiogenic shock that the primary diseases can be cured, the vital end organ damage can recover, there are modes of organ support for waiting organ recovery, age of patients should not be too old, and not at a terminal stage of diseases. The ECMO team is available all the time and will make decisions to initiate ECMO treatment.

In-hospital survival rate in the present study meant the number of patients under VA ECMO treatment and discharged from the hospital compared to total patients. Wean off VA ECMO rate meant the number of proposed weaning patients who were strong enough to wean off ECMO and not re-cannulate VA ECMO compared to the total patients. Nosocomial infection during on ECMO meant infection that culture positive after starting cannulating VA ECMO within 48 hours until 24 hours after weaning off ECMO. Life threatening bleeding was as defined by Bleeding Academic Research Consortium (BARC) definition more than 3a[9]. Major vascular complication was as defined by the Valve Academic Research Consortium (VARC) 2[10]. Expense course of VA ECMO meant the total amount of money paid to hospital for admission using VA ECMO. History cardiac arrest before on ECMO meant patients who had cardiac arrest in the admission before on VA ECMO. Thirty days and 1-year survival meant patients who were still alive from day 1 on ECMO treatment to 30 days or 365 days.

Statistical analysis

Based on the present sample size of 81 samples, the expected survival rate in the present study was 26.5%(10). There would be at least 75 patients to be used in the study for type I error=0.05 and type II error=0.1. T-test, Mann-Whitney U test, chi-squared and Fisher's exact test were used to analyze the difference of each factor between survival group and non-survival group. The authors used t-test for continuous normal distribution variables, Mann-Whitney U test for non-continuous normal distribution variables, and chi-squared or Fisher's exact test for categorical data with dummy variables. The significant level of difference between the two groups was determined at p-value 0.05.

After screening the difference of each factor between the two groups by statistical distributions, all significant factors with p-value less than 0.1 would be further analyzed for their impact on survival outcomes by Univariate analysis. These factors would be further processed into Multivariate Logistic Regression Analysis to see the corelated impacts among factors. In multivariate regression, using stepwise approach by choosing factors that had p-value less than 0.1 to enter the next step of regression analyses. The significant impact of factors at the results were expressed as odd ratio (OR), 95% confidence intervals (CIs), and p-value. All statistical significance was p-value less than 0.05. Finally, Kaplan-Meier analysis was used to analyze survival rate at 30 days and at 1-year. Stata, version 12 (StataCorp LP, College Station, TX, USA) was used to analyze the data.

Results

Baseline characteristics, laboratory, and echocardiography before on VA ECMO

The authors reviewed the ECMO database from perfusionist between January 1, 2012 and July 1, 2019. There were 136 patients on ECMO. Among these, 29 patients were excluded because they were not on VA ECMO and 22 patients were excluded due to younger than 15 years old, and three were excluded because of missing diagnosis. One was excluded because of starting cannulating VA ECMO outside

Table 1. Baseline characteristics

Factor	All patients (n=81); n (%)	Survive (n=20); n (%)	Death (n=61); n (%)	p-value
Age (years); mean±SD	54.59±18.55	54.25±17.77	54.7±18.95	0.92
Sex: male	46 (57)	13 (65)	33 (54)	0.39
Body mass index (kg/m^2); mean±SD	22.71±1.07	22.08±1.05	22.92±0.51	0.43
Body weight (kg); mean±SD	61.74±14.76	58.30±13.09	62.88±15.20	0.23
Dyslipidemia	20 (25)	6 (30)	14 (23)	0.56
Diabetes mellitus	14 (17)	5 (25)	9 (15)	0.32
Hypertension	26 (32)	8 (40)	18 (30)	0.38
Stroke	7 (9)	1 (5)	6 (10)	0.68
VHD or post valve surgery	16 (20)	4 (20)	2 (3)	1
SCAD/MI	16 (20)	5 (25)	11 (18)	0.53
History of cardiac arrest before VA ECMO	35 (43)	8 (40)	27 (44)	0.74
Place of start ECMO				0.73
Coronary care unit	36 (45)	11 (55)	25 (41)	
Intensive care unit CVT	39 (48)	8 (40)	31 (51)	
Intensive care unit medicine	4 (5)	1 (5)	3 (5)	
Other	2 (2)	0 (0)	2 (3)	
Year of admission				0.10
2012 to 2016	25 (31)	3 (15)	22 (36)	
2517 to 2019	56 (69)	17 (85)	39 (64)	
Indication for ECMO				0.80
Bridge to decision	2 (2)	0 (0)	2 (3)	
Bridge to recovery	61 (75)	17 (85)	44 (72)	
ECPR	17 (21)	3 (15)	14 (23)	
Bridge to transplant	1 (10)	0 (0)	1 (20)	
Etiology			6	0.86
Cardiac arrest (ECPR)	17 (21)	3 (15)	14 (23)	
Post cardiotomy cardiogenic shock	24 (30)	6 (30)	18 (29)	
Acute coronary syndrome	16 (20)	5 (25)	11 (18)	
Other chronic cardiomyopathy	10 (12)	3 (15)	7 (11)	
Graft rejection post heart transplantation	1 (1)	0 (0)	1 (2)	
Myocarditis	7 (9)	3 (15)	4 (7)	
Post heart or lung transplantation	4 (5)	0 (0)	4 (7)	
Pulmonary embolism	1 (1)	0 (0)	1 (2)	
Trauma (blunt abdominal)	1 (1)	0 (0)	1 (2)	
Heart rate (beat/minute); median (IQR)	106 (69 to 128)	105 (76.5 to 135)	109 (61 to 126)	0.56
Body temperature (°C); mean±SD	36.2±1.17	36.38±1.17	36.14±1.18	0.44
Adrenaline dose (mcg/kg/minute)	0.68 (0.1 to 1.04)	0.44 (0.1 to 1.0)	0.7 (0.1 to 1.33)	0.29
Norepinephrine* (mcg/kg/minute); median (IQR)	0 (0 to 0.27)	0 (0 to 0.05)	0 (0 to 0.31)	0.08
Glasgow coma scale; mean±SD	7.95±3.58	9.6±2.85	7.41±3.65	0.02
On intraarotic balloon pump	46 (57)	11 (55)	35 (35)	0.85
Laboratory data				
Hemoglobin (g/dL); mean±SD	11.26±2.69	11.88±2.51	11.06±2.75	0.24
White blood cell count (/uL); median (IQR)	13,640 (8,850 to 19,850)	14,195 (9475 to 21,800)	13,560 (7,090 to 19,740)	0.42
Platelet (/uL); median (IQR)	163,000 (101,000 to 235,000)	199,000 (120,500 to 230,000)	150,000 (9,900 to 239,000)	0.33
Total bilirubin (mg/dL); median (IQR)	1.54 (0.79 to 2.82)	1.69 (0.73 to 2.5)	1.47 (0.81 to 2.9)	0.88
Direct bilirubin (mg/dL); median (IQR)	0.9 (0.4 to 1.77)	0.89 (0.37 to 1.69)	0.91 (0.4 to 1.77)	0.99
Aspartate aminotransferase (U/L); median (IQR)	230 (58 to 770)	100.5 (42.5 to 911.5)	262 (95 to 701)	0.29
Alanine aminotransferase (U/L); median (IQR)	101 (40 to 371)	80.5 (21 to 244.5)	112 (49 to 435)	0.39
Creatinine (mg/dL); median (IQR)	1.52 (1.06 to 2.16)	1.37 (1.4 to 1.78)	1.69 (1.06 to 2.4)	0.28
Sodium (mmol/L); mean±SD	141.35±8.59	138.15±8.16	142±8.53	0.06
PaO_2/FIO_2 ratio; median (IQR)	242.0 (80.8 to 502.5)	364.0 (219.17 to 602.14)	190.0 (74.0 to 459.5)	0.06
Lactate (mmol/L); median (IQR)	11.5 (7.2 to 15.8)	7.65 (3.35 to 13.7)	13.6 (8.4 to 16.5)	0.02
pH; mean±SD	7.29±.17	7.33±0.18	7.28±0.17	0.22
Arterial blood gas PaO_2 (mmHg); median (IQR)	131 (76 to 343)	200 (111 to 347.1)	120 (64 to 343)	0.17
Arterial blood gas $PaCO_2$ (mmHg); median (IQR)	31.3 (27 to 41.3)	28.65 (22.4 to 31.8)	34 (27 to 41.3)	<0.01
Scoring				
SAVE score; median (IQR)	−3 (−7 to 2)	−3 (−5.5 to 1.5)	−3 (−7 to 2)	0.45
Mortality rate by SAVE score; mean±SD	0.43±0.18	0.44±0.15	0.42±0.19	0.62
APACHE II score; mean±SD	31.58±8.7	28.05±6.07	32.75±9.15	0.04
Mortality rate by APACHE II score; mean±SD	0.66±0.19	0.59±0.2	0.68±0.18	0.04
SOFA score; mean±SD	11.28±3.32	9.7±2.47	11.79±3.42	0.01
Mortality rate by SOFA score; mean±SD	0.64±0.3	0.50±0.25	0.7±0.3	0.01
Bicarbonate (mmol/L); mean±SD	17.60±6.61	17.15±5.38	17.75±7.0	0.73

VHD=valvular heart disease; SCAD=stable coronary artery disease; MI=myocardial infarction; VA ECMO=venoarterial extracorporeal membrane oxygenation; CVT=cardiac vascular and thoracic; ECMO=extracorporeal membrane oxygenation; ECPR=extracorporeal cardiopulmonary resuscitation; PaO_2/FIO_2=partial pressure arterial oxygen and fraction of inspired oxygen; PaO_2=partial pressures of oxygen; $PaCO_2$=partial pressures of oxygen carbon dioxide; SAVE=survival after veno-arterial ECMO; APACHE II=Acute Physiologic Assessment and Chronic Health Evaluation II; SOFA=Sequential Organ Failure Assessment IQR=interquartile range; SD=standard deviation

* Norepinephrine were used in 35 patients (6 survived patients and 29 death patients)

Table 2. Echocardiographic data before VA ECMO

	All patient (n=77); median (IQR)	Survival (n=20); median (IQR)	Death (n=57); median (IQR)	p-value
LV function				
LVEF (%)	30 (20 to 53)	20 (17.5 to 44.5)	36 (22 to 55)	0.06
LV diameter (cm)	(n=73)	(n=19)	(n=54)	
• LVEDD	4.7 (3.7 to 5.2)	5.2 (4 to 6.4)	4.55 (3.5 to 5.1)	0.07
• LVESD	3.6 (2.9 to 4.6)	4.5 (3.1 to 5.5)	3.35 (2.8 to 4.2)	0.09
RV function	(n=47)	(n=10)	(n=37)	
TAPSE (cm)	1.4 (0.9 to 1.9)	1.85 (1.1 to 2.9)	1.4 (0.74 to 1.7)	0.06

IQR=interquartile range; LVEF=left ventricular ejection fraction; LVEDD=left ventricular end diastolic diameter; LVESD=left ventricular end systolic diameter; TAPSE=tricuspid annular plane systolic excursion

KCMH. Subsequently, there were 81 patients included in the present study.

Baseline characteristics are shown in Table 1. The patients average age was 54.59 years old with 46 male (56.79%) and 35 female patients (43.21%). The average body mass index (BMI) was 22.71 kg/m². Underlying diseases of patients were hypertension 32.1%, diabetes mellitus 22.71%, dyslipidemia 22.69%, coronary artery disease 19.75%, and others, as shown in Table 1 and 2.

The reasons for patients to cannulate VA ECMO were post cardiotomy syndrome with cardiogenic shock with 24 patients (29.63%), ECPR with 17 patients (19.75%), and for other reasons for 40 patients (49.38%). The rate of survival to discharge in post cardiotomy syndrome with cardiogenic shock was 25%, while ECPR was 17.65%, and for other reasons was relatively high at 27.5%. The overall survival to discharge was 24.69% and weaning rate of VA ECMO was 35.8%. Details are shown in Table 1.

Between the survival group and the non-survival group, there were significant differences in baseline characteristics such as year of admission, Glasgow Coma Scale (GCS), lactate, arterial blood gas carbon dioxide (ABG $PaCO_2$), SAVE score, Acute Physiologic Assessment and Chronic Health Evaluation II (APACHE II) score, predicted mortality rate by APACHE II score, Sequential Organ Failure Assessment (SOFA) score, and predicted mortality rate by SOFA score. Results were shown in Table 1.

In Univariate Analysis, the authors analyzed the impact on survival of the following factors before on VA ECMO, dose of norepinephrine, blood level of sodium (Na), PaO_2/FIO_2 ratio, left ventricular ejection fraction (LVEF), left ventricular end diastolic dimension (LVEDD), left ventricular end systolic dimension (LVESD), tricuspid annular plane systolic excursion (TAPSE), GCS, ABG $PaCO_2$, lactate, APACHE II score, mortality rate by APACHE II score, SOFA score, and mortality rate by SOFA score. The authors found that factors that had significant impact on survival rate before on VA ECMO were higher GCS [OR 1.243 (1.026 to 1.508); p=0.026], lower ABG $PaCO_2$ [OR 0.908 (0.848 to 0.973); p=0.007), lower blood level of lactate (OR 0.890 (0.808 to 0.979); p=0.018), lower APACHE II score (OR 0.935 (0.877 to 0.998); p=0.045), lower the SOFA scores [OR 0.810 (0.680 to 0.965); p=0.018), and lower predicted mortality rates by SOFA scores (OR 0.977 (0.959 to 0.995); p=0.015). Results are shown in Table 3.

For multivariate analysis, factors included into the regression were norepinephrine, LVEF, ABG $PaCO_2$, level of blood lactate and sodium, APACHE II score, SOFA score, while GCS was excluded from multivariate due to high correlation with SOFA or APACHE II score. In addition, lower ABG $PaCO_2$ and lactate were significant factors that affected survival rate (OR 0.91; 95% CI 0.85 to 0.98 and 0.90; 95% CI 0.81 to 0.99, respectively). Results are shown in Table 4.

Complications of VA ECMO and outcomes

There were 29 patients having nosocomial infection during on VA ECMO, representing a rate of 35.8%. Median of first infection was 7.63 (4 to 25) days. Fifty-two infections were found. Among these, 27 were from sputum, 18 were from H/C, five were from urine C/S, and two were from tissue culture. The most common pathogen was *Pseudomonas aeruginosa* (23.07%). Details are shown in Table 5 and 6.

Forty-five patients (55.56%)underwent renal replacement therapy (RRT) in the present study. There were 45 patients having life threatening bleeding complication (55.56%), 36 patients in

Table 3. Significant impact of baseline characteristics by univariate analysis

Variable	Odd ratio (95% CI)	p-value
Norepinephrine	0.767 (0.004 to 1.602)	0.098
Sodium	0.943 (0.884 to 1.002)	0.059
PaO_2/FI O_2 ratio	1.001 (0.997 to 1.002)	0.105
LVEF	0.980 (0.952 to 1.003)	0.081
LVEDD	1.340 (0.929 to 1.934)	0.118
LVESD	1.317 (0.909 to 1.908)	0.146
TAPSE	2.183 (0.615 to 7.782)	0.229
Glasgow Coma Scale	1.243 (1.026 to 1.508)	0.026
Arterial blood gas $PaCO_2$	0.908 (0.848 to 0.973)	0.007
Lactate	0.890 (0.808 to 0.979)	0.018
APACHE II	0.935 (0.844 to 0.998)	0.045
Mortality rate from APACHE II score	0.974 (0.948 to 1.000)	0.051
SOFA score	0.810 (0.680 to 0.965)	0.018
Mortality rate from SOFA score	0.977 (0.959 to 0.995)	0.015

CI=confidence interval; PaO_2/FIO_2 ratio=partial pressure arterial oxygen and fraction of inspired oxygen ratio; LVEF=left ventricular ejection fraction; LVEDD=left ventricular end diastolic diameter; LVESD=left ventricular end systolic diameter; TAPSE=tricuspid annular plane systolic excursion; $PaCO_2$=partial pressure of oxygen carbon dioxide; APACHE II=Acute Physiologic Assessment and Chronic Health Evaluation II; SOFA=Sequential Organ Failure Assessment

major vascular complication (44.44%), 17 patients in stroke (20.99%), and 10 patients in other types of complications (12.35%).

The survival rate during on VA ECMO was 24.69%. Wean off rate was 35.8%. The mean length of stay was 14 (7 to 28) days and duration of cannulating VA ECMO was 6.11 (2.18 to 10.60) days. The average total admission cost for patient who received VA ECMO per one patient was 35,475.5 USD.

Survival rate was affected by life threatening bleeding complication, length of stay, and duration of using VA ECMO. There were no differences between death and in-hospital survival in nosocomial infection, RRT, and major vascular and stroke complication. The three most common causes of death in the present study were from their presenting diseases for 26 patients (42.62%), bleeding complication for 14 patients (22.95%), and infection for 11 patients (18.03%). Details are shown in Table 7.

Table 4. Significant impact of univariate analysis by multivariate analysis

Variable	Odd ratio (95% CI)	p-value
Lactate	0.90 (0.81 to 0.99)	0.033
Norepinephrine	0.082 (0.002 to 3.92)	0.205
LVEF	0.98 (0.95 to 1.01)	0.196
APACHE II score	0.94 (0.86 to 1.03)	0.175
SOFA score	0.94 (0.75 to 1.18)	0.619

CI=confidence interval; LVEF=left ventricular ejection fraction; $PaCO_2$= partial pressures of oxygen carbon dioxide; APACHE II=Acute Physiologic Assessment and Chronic Health Evaluation II; SOFA=Sequential Organ Failure Assessment

The authors further analyzed the impact on survival of the following factors by univariate analysis, life threatening bleeding, duration of using VA ECMO, and length of stay. All these factors had significant impact on survival rate, with results shown in Table 8.

In 30-day survival analysis, the incidence density was 4.78 per 100 patients per day and median time to death was 11 days (95% CI 7 to 16). In the 1-year survival analysis, the incidence density was 57.91 per 100 patients per month, and the median time to death was 0.3 month (95% CI 0.17 to 0.43). Results are shown in Figure 1.

Table 5. Complication and outcomes

Factor	All patient (n=81); n (%)	Survive (n=20); n (%)	Death (n=61); n (%)	p-value
Nosocomial infection culture positive	29 (36)	9 (45)	20 (33)	0.32
RRT before or during ECMO	45 (56)	8 (40)	37 (61)	0.20
Life threatening bleeding	36 (44)	5 (25)	31 (51)	0.04
Major vascular complication	17 (21)	4 (20)	13 (21)	1
Stroke (%)	10 (12)	2 (10)	8 (13)	1
Budget in ECMO (Baht); median (IQR)	1,064,265 (584,857 to 1,161,091)	1,483,232 (927,561 to 1,277,782)	9,298,780 (465,357 to 1,103,586)	0.02
Wean off ECMO successful	29 (36)	20 (10)	9 (15)	<0.01
Length of stay (days); median (IQR)	14 (7 to 28)	38.5 (19 to 58.5)	10 (4 to 20)	<0.01
Duration of using VA ECMO (days); median (IQR)	6.11 (2.18 to 10.60)	8.74 (5.93 to 12.54)	5.47 (1.23 to 10.29)	0.01

RRT=renal replacement therapy; ECMO=extracorporeal membrane oxygenation; SAVE=survival after veno-arterial ECMO; APACHE II=Acute Physiologic Assessment and Chronic Health Evaluation II; SOFA=Sequential Organ Failure Assessment; IQR=interquartile range

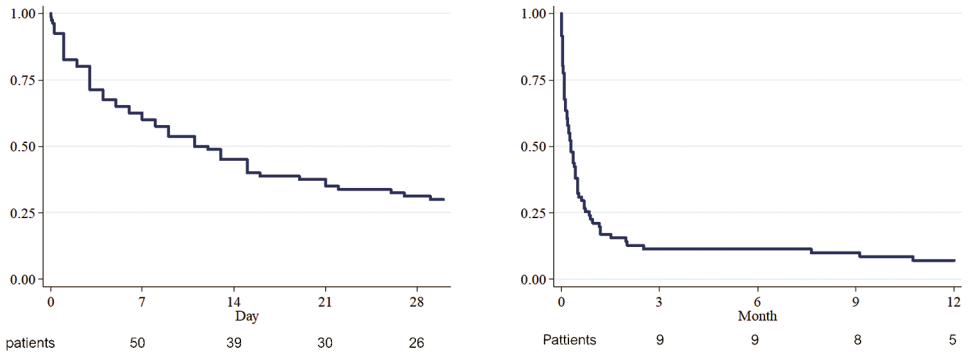

Figure 1. Kaplan-Meier analysis survival at 30 days and 1 year.

Table 6. Details of pathogen in culture positive

Organism	Number of cultures (n=52); n (%)
Pseudomonas aeruginosa	12 (23)
Klebsiella pneumoniae	7 (13)
Stenotrophomonas maltophilia	6 (12)
Escherichia coli	5 (10)
Acinetobacter baumannii	4 (8)
Enterobacter cloacae	4 (8)
Staphyloccoccus coagulase negative	3 (6)
Other pathogens	11 (21)

Table 7. Causes of death

Cause of death	Number of patients; n (%)
Presenting disease	26 (42.62)
Bleeding complication	14 (22.95)
Infection	11 (18.03)
Stroke	5 (8.20)
Ischemic bowel disease	2 (3.28)
Other etiology	3 (4.92)

Table 8. Complications and outcomes by univariate analysis

Variable	Odd ratio (95% CI)	p-value
Life threatening bleeding	0.32 (0.10 to 0.998)	0.05
Duration of using VA ECMO	0.91 (0.85 to 0.98)	0.02
Length of stay	1.07 (1.03 to 1.11)	<0.01

CI=confidence interval; VA ECMO=venoarterial extracorporeal membrane oxygenation

Discussion

Primary outcome and baseline characteristic before on VA ECMO

The survival rate of patients on VA ECMO in the present study was 24.69%. This rate is at the lower bounds of the range of survival rates in literature, which was around 20% to 60%. Compared with Schmidt et al study, which indicated relatively high survival rate at 42%, it may be possible to explain the underlying reasons for the low survival rate in the present study compared to other countries. In both studies, average age of patients was around 55 years. However, rate of prior CPR in Schmidt et al study was 32%, which is lower than the present study at 43.2%. In addition, rates of organ failures in their study were also lower. In their study, the rate of liver failure was 5%, central nervous system (CNS) dysfunction was 6%, and renal failure was 14%, while in the present study, by using same criteria of measurements and same definitions, rate of liver failure was 80.2%, CNS dysfunction was 40.7%, and renal failure was 17.3%[6]. This indicated that patients in the present study were more severe and complicated, and they might be too late to cannulate ECMO. States of weakness and sickness led to lower survival rate in the present study. In addition, experiences in providing VA ECMO treatment may also affect the survival rate. Although, the survival rate between 2017 and 2019 is higher than 2012 and 2016, the result was not statistically significant, and the results are shown in Table 9. This might also be confirmed by previous studies that indicated that more experienced VA ECMO center can make survival rate better[11,12]. Compared to developed countries, VA ECMO treatment is still relatively new to Thailand. This added on another reason to explain the present relatively low survival rate.

Based on univariate analysis, the factors that affect survival at baseline were higher GCS, lower ABG $PaCO_2$, lower blood level of lactate before using VA ECMO, lower APACHE II and SOFA scores, and lower predicted mortality rates by SOFA scores. In

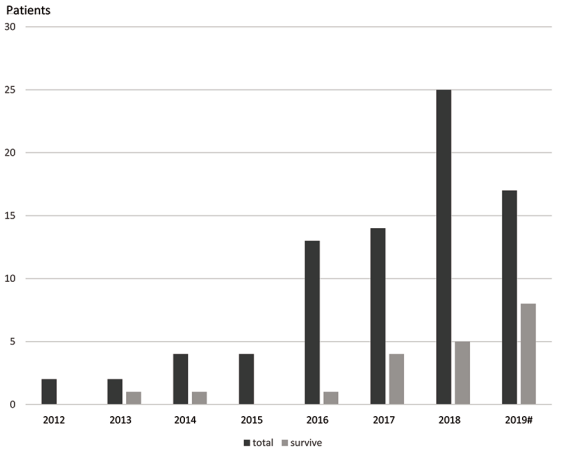

Figure 2. Annual survival rate between 2012 and 2019.

In 2019, data was collected from only first 6 months

Table 9. Severity of patient sickness compared different periods

Years of start ECMO	2012 to 2016	2017 to 2019	p-value
Survival rate; n (%)	12	30	0.098
APACHE II score; mean±SD	32.13±8.63	31.34± 8.79	0.71
Lactate (mmol/L); median (IQR)	9.84 (6.3 to 14.1)	11.86 (7.2 to 15.8)	0.17

SD=standard deviation; IQR=interquartile range; ECMO=extracorporeal membrane oxygenation

multivariate analysis, lower ABG $PaCO_2$ and lactate were significant factors that led to higher survival (OR 0.91, 95% CI 0.85 to 0.98 and 0.90, 95% CI 0.81 to 0.99, respectively). These results were similar to the study of Wei Cheng Chen. In his study, the lower lactate was, the higher of the survival. Lactate is produced from anaerobic glycolysis due to cellular hypoxemia[13]. Several studies showed that the higher of lactate means the higher of mortality[14-16].

As for lower ABG Pa CO_2 impacting higher survival, this conclusion is still controversial. There is the study in children VA ECMO that found that hypercarbia was a factor associated with mortality rate[17], but another study could not find the impact of this factor[18]. Changing of ABG $PaCO_2$ in blood can cause cerebral vasculature change[17,18]. Hypercapnia can cause cerebral vessel vasodilatation and increase intracranial pressure. Hypocapnia can cause cerebral vasoconstriction. However, too much hypocapnia may cause cerebral ischemia.

Complications and outcomes of VA ECMO

The weaning rate in the present study was 35.8%. In literature, the weaning rate of VA ECMO was 31% to 66%, while most were around 31% to 40%[19-22]. In those studies, 72.41% of patients could survive after weaning off VA ECMO. Longer length of stay and duration of using ECMO were associated with lower mortality rate. The very-sick patients, usually died during first few days of VA ECMO insertion. The results of the present study were the same as previous studies[12,23-25].

The most common complication in the present study was renal failure with RRT 55.56%. Rate of RRT from previous studies was around 33% to 46%[7,26,27]. Obviously, the present study had higher rate of RRT. This might be caused by patients' delay of cannulating VA ECMO.

Nosocomial infection was associated with longer length of hospitalization. From the previous studies, the duration of more than seven days would increase rate of infection[28]. However, surprisingly the nosocomial infection did not affect mortality rate. The very-sick patients might die before having infection. As a result, patients who could survive were associated with longer length of stay[29]. Most common sites of infection are from respiratory tract infections, which was in line with the previous studies[28,29]. Consequently, physicians should be more careful about hospital and ventilator acquired pneumonia. Most common pathogen were *Pseudomonas aeruginosa* (23.07%).

About bleeding complication, the present study showed the bleeding complication was a significant factor to decrease rate of survival [OR 0.32 (0.10 to 0.998), p=0.05], which was also similar to the previous studies[30].

Limitation

The present study was conducted retrospectively, therefore, some missing data were inevitable. In addition, this was a small single center study, so generalizability of the study results could not be applied.

Conclusion

VA ECMO can rescue refractory cardiogenic shock. However, the mortality rate is still high. VA ECMO treatment is expensive and requires lots of resources. The cost of VA ECMO is another factor to be concerned, particularly in the developing country. As a result, the factors that have high impact on patient survival can be identified and be carefully considered before accepting a patient to cannulate VA ECMO. In the present study, lower lactate and lower ABG $PaCO_2$

are important factors impacting patient survival rate. Complications and outcome such as life-threatening bleeding, duration of using VA ECMO, and length of stay are among factors that have significant impact. Respiratory tract infection is the most common of nosocomial infection that should not be overlooked.

What is already known on this topic?

Patients who presented with cardiogenic shock and required VA ECMO for cardiopulmonary support had high in-hospital mortality rate due to disease itself, bleeding complication, and infection.

What this study adds?

The outcomes in Thai patients also have the same outcomes as in the previous studies. The lower serum lactate and ABG $PaCO_2$ are the new predictors impacting higher survival.

Conflicts of interest

The authors declare no conflict of interest.

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