Age Differences in Venoarterial Extracorporeal Membrane Oxygenation for Cardiogenic Shock: Trends in Application and Outcome From the Chinese Extracorporeal Life Support Registry

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Venoarterial extracorporeal membrane oxygenation (VA-ECMO) is increasingly used for cardiogenic shock (CS) in adults, with age-influencing outcomes. Data from the Chinese Extracorporeal Life Support (CSECLS) Organization registry (January 2017–July 2023) were analyzed to assess in-hospital mortality in VA-ECMO for CS. Patients ≤65 years were categorized as young, and those >65 as elder. The primary outcome was in-hospital mortality, with secondary outcomes including ECMO weaning, 30 day survival, and complications. Of 5,127 patients, the young group (73.4%) had a median age of 51.0 (40.0–58.0) years, and the elder group (26.6%) had a median age of 71.0 (68.0–75.0) years. The in-hospital mortality was lower in the younger group (45.1%) compared with the elder group (52.6%, $p < 0.001$). The young group also had higher ECMO weaning rates (79.4% *vs.* 74.8%, $p < 0.001$) and 30 day survival (59.1% *vs.* 51.3%, $p < 0.001$). Bleeding, renal, and pulmonary complications were more frequent in young patients, though not statistically significant. Young patients undergoing VA-ECMO for CS generally have better outcomes than older patients, though careful selection is crucial to manage complications. *ASAIO Journal* 2025; 71:579–587

Key Words: VA-ECMO, the CSECLS registry, cardiogenic shock, ECMO survival, ECMO in the young

Cardiogenic shock (CS) is characterized by acute organ perfusion insufficiency and is a severely life-threatening condition. Guidelines recommend the early application of mechanical circulatory support in refractory CS.[1] Venoarterial extracorporeal membrane oxygenation (VA-ECMO) is widely used in CS of various etiologies, including acute myocardial infarction (AMI), electrical storms, myocarditis, and pulmonary embolism.[2–4] Despite its broader use, the application of VA-ECMO remains controversial and is a relative contraindication for elderly patients in many centers.[5–7] Among young patients, the utilization of VA-ECMO has not been clearly defined, and risk factors for survival to hospital discharge in these patients remain unreported. Therefore, we analyzed data from the CSECLS registry to evaluate VA-ECMO outcomes among the patients and to identify risk factors associated with in-hospital mortality.

Methods

Design and Data Source

We retrospectively evaluated consecutive patients who received VA-ECMO between January 2017 and July 2023 from the CSECLS registry, a voluntary database that collects information on ECMO use, complications, and outcomes in adults and children from over 112 member centers in China. Data were collected using a standardized electronic reporting sheet submitted *via* the organization's website.

Patients with CS undergoing VA-ECMO were screened as shown in Figure 1. The inclusion criteria for this study were: 1) patients who received VA-ECMO for CS between January 2017 and July 2023 and 2) age greater than 18 years. Patients were

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K.W., L.W., J.M., H.X., X.H., Z.D., and C.L. collected and analyzed the patient data. K.W., J.M., and L.W. performed the statistical analysis. K.W., L.W., and H.W. were major contributors in writing the manuscript. All authors read and approved the final manuscript.

The study was approved by the institutional ethics committee/review board of the Beijing Anzhen Hospital. Informed consent for demographic, physiologic, and hospital outcome data analyses was not obtained because his observational study did not modify existing diagnostic or therapeutic strategies.

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Supplemental digital content is available for this article. Direct URL citations appear in the printed text, and links to the digital files are provided in the HTML and PDF versions of this article on the journal's Web site (www.asaiojournal.com).

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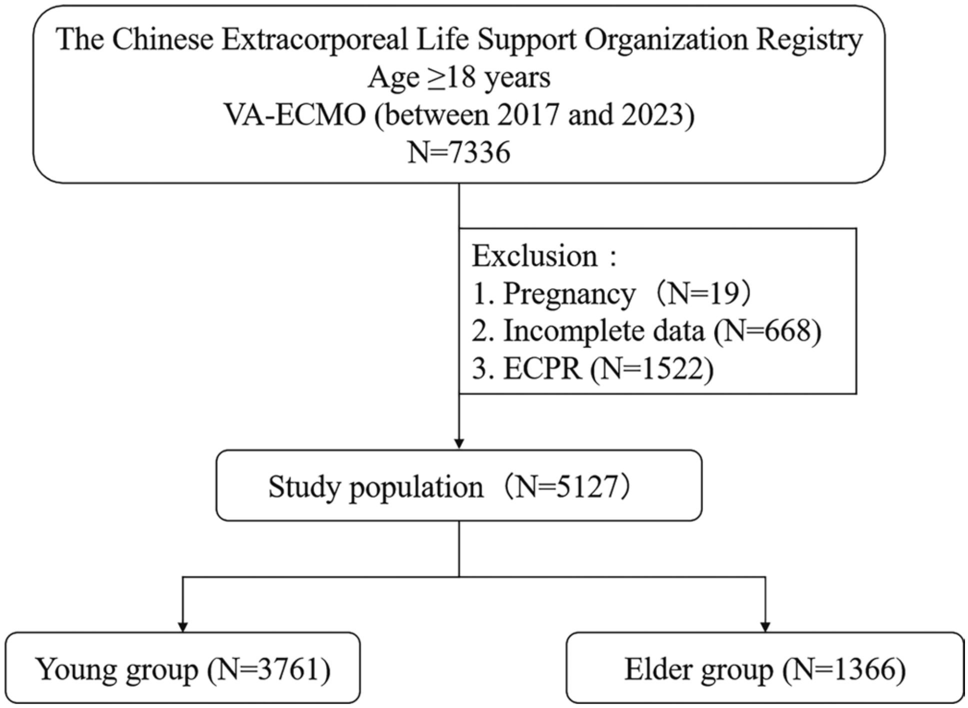

Figure 1. Study flowchart. ECPR, extracorporeal cardiopulmonary resuscitation; VA-ECMO, venoarterial extracorporeal membrane oxygenation.

excluded if they met any of the following criteria: 1) pregnant, 2) incomplete data, and 3) receiving extracorporeal cardiopulmonary resuscitation (ECPR) for cardiac arrest (CA), because ECPR patients typically represent a more critical group with very different management strategies and outcomes compared with other VA-ECMO patients. For the purposes of this study, young patients were defined as those ≤65 years old at the time of ECMO initiation. The remaining patients served as the elderly cohort.

The primary outcome was in-hospital mortality. Secondary outcomes included 30 day mortality, successful weaning from, and various complications including mechanical (any of the following: membrane lung oxygenation impairment, tubing rupture, joint cracking, heat exchanger warming malfunction, intubation problems, and thrombosis), bleeding (any of the following: gastrointestinal bleeding, bleeding at intubation, surgery-related bleeding, hemolysis, Free Hemoglobin (FHb) >50 mg/dl, and disseminated intravascular coagulation), neurologic (any of the following: cerebral hemorrhage, cerebral infarction, seizures, and brain death), renal (any of the following: elevated creatinine and continuous renal replacement therapy), pulmonary (any of the following: pneumothorax, pulmonary hemorrhage, and infection), metabolic (any of the following: glucose <40 mg/dl, glucose >240 mg/dl, PH <7.2, and PH >7.6), and limb complications (any of the following: distal ischemia, necrosis, fasciotomy techniques, amputation, removal of embolus, and endoluminal stripping). The study was approved by the institutional ethics committee board of the Capital Medical University, Beijing Anzhen Hospital.

Statistical Analysis

All statistical analyses were performed using SPSS 19.0 (SPSS Inc., Chicago, IL) and R 4.3.2 (http://www.R-project.org). Patient characteristics were reported as median values with interquartile range (IQR) for continuous variables, or frequency with proportion for categorical variables. Continuous variables were compared using the Student's t-test or the Mann-Whitney *U* test, while categorical data were analyzed using Fisher's exact test or Pearson's χ^2 test. Significant and borderline significant values ($p < 0.1$) were entered into stepwise forward multivariable logistic regression, including age as a continuous covariate, to estimate factors associated with mortality before hospital discharge. The cumulative 30 day survival rates after ECMO initiation were analyzed using the Kaplan–Meier method, with intergroup comparisons performed using the log-rank test. Restricted cubic splines were used to explore associations between age and 30 day mortality. For sensitivity analysis, logistic regression models were generated to assess the factors influencing in-hospital mortality and ECMO weaning success among patients undergoing VA-ECMO support across important subgroups of gender, young, and subgroup of age (18–45, 46–64, 65–74, and ≥75), obesity status (BMI <24 and ≥24), pre-ECMO diagnosis (including myocarditis, postcardiotomy shock [PCS], AMI, chronic heart failure, and sepsis), large center (more than 30 cases annually), pre-ECMO transfer, and pre-ECMO CA. All variables were adjusted for gender, age, BMI, pre-ECMO PH and lactate levels, medical history, and pre-ECMO CA. The subgroup of patients aged 46–64 years was classified into two groups (≤55 and >55) for analysis. *p* values less than 0.05 were considered statistically significant.

Results

There were 5,127 patients in the CSECLS registry with VA-ECMO support available for data assessment (Figure 1).

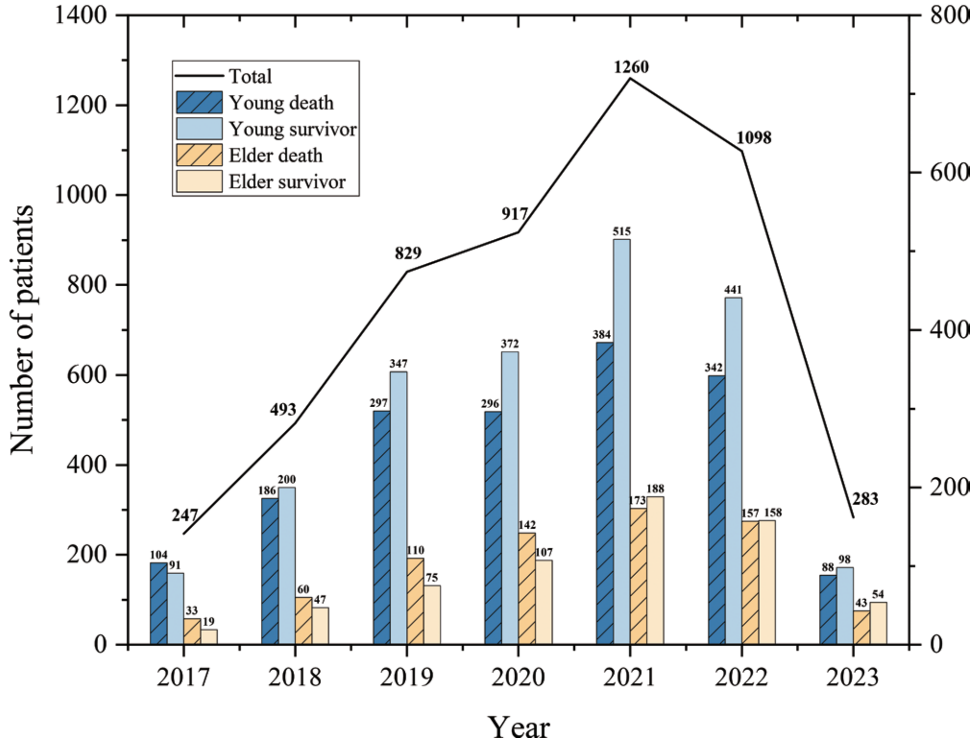

Figure 2. The annual number of VA-ECMO case volume and mortality. VA-ECMO, venoarterial extracorporeal membrane oxygenation.

Figure 2 shows the annual number of VA-ECMO cases and mortality rates between the young and elder groups. The total number of VA-ECMO cases increased from 247 in 2017 to 1,260 in 2021 but decreased to 1,098 in 2022. Generally, the application of VA-ECMO was higher in the young group than in the elder group from 2017 to 2019, but this trend reversed from 2020 to 2023. Among the 5,127 patients, 2,712 (52.9%) survived to discharge. The rate of in-hospital mortality was lower in the young group (45.1%) compared with the elder group (52.6%) (Table 1) ($p < 0.001$). Overall, in-hospital mortality improved from 2017 to 2021.

The patient characteristics are shown in Table 1. The mean age was 54.7 ± 15.2 years, and the majority of patients were male (70.4%) ($p = 0.023$). Among the study patients, 73.4% were in the young group and 26.6% were in the elder group. The mean age was 48.4 ± 12.4 years for the young group and 72.2 ± 5.36 years for the elder group. There was a higher rate of CA before ECMO in the young group compared with the elder group (26.9% *vs.* 21.7%, $p < 0.001$). The most common indication for ECMO insertion was AMI (23.5%), followed by myocarditis (11.9%) and PCS (11.4%). The young group exhibited a higher percentage of PCS and myocarditis and a lower percentage of AMI compared with the elderly group ($p < 0.001$). The young group also had fewer comorbidities than the elderly group ($p < 0.001$), including cardiac intervention, myocardial infarction, hypertension, diabetes, hyperlipidemia, heart failure, nervous system dysfunction, chronic respiratory diseases, and the use of anticoagulants. Pre-ECMO patient information showed differences between the young and elderly groups, with faster heart rates ($p < 0.001$), lower ejection fractions (EF) ($p < 0.001$), lower lactate levels ($p = 0.028$), and higher rates of mechanical ventilation ($p = 0.009$) and vasopressor use ($p = 0.003$) in the young group. However, there was a wider variety of vasopressors used in the elderly group. More patients in the elderly group (51.3%) received ECMO in large center than in the young group (39.9%, $p < 0.001$).

The hospital outcomes for all study patients are listed in Table 2. Regarding clinical outcomes, the young group had a lower in-hospital mortality rate compared with the elderly group (45.4% *vs.* 52.6%, $p < 0.001$) and a higher rate of weaning from ECMO (79.4% *vs.* 74.8%, $p < 0.001$). The 30 day survival rate was also higher in the young group than in the elderly group ($p < 0.001$) (Figure 3). In terms of complications, the young group had lower rates of mechanical, neurologic, metabolic, and limb complications compared with the elderly group, but these differences were not statistically significant. However, the young group experienced higher rates of bleeding, renal, and pulmonary complications, although these differences were also not statistically significant.

Multifactorial logistic regression analysis revealed several significant risk factors affecting prognosis. These factors included age, history of cerebrovascular accident and sequelae, CA before ECMO, systolic blood pressure (SBP) before ECMO, pH before ECMO, lactate level before ECMO, use of vasopressors before ECMO, and indications for ECMO such as PCS, AMI, chronic heart failure, and sepsis. Specifically, chronic heart failure before ECMO posed the highest risk, followed by PCS, sepsis, and AMI in descending order. The risk of poor prognosis increased with the number of different types of vasopressors used before ECMO (Figure 4).

The logistic regression analysis revealed that age significantly influenced both in-hospital mortality and the success of ECMO weaning. For in-hospital mortality, the overall cohort

Table 1. Demographic and Clinical Characteristics of the Study Population

	Overall (N = 5,127)	Young Group (N = 3,761)	Elder Group (N = 1,366)	p Value
Age	56.0 (45.0–66.0)	51.0 (40.0–58.0)	71.0 (68.0–75.0)	<0.001
Gender				0.023
Male	3,608 (70.4%)	2,680 (71.3%)	928 (67.9%)	
Female	1,519 (29.6%)	1,081 (28.7%)	438 (32.1%)	
Weight	66.0 (60.0–75.0)	68.0 (60.0–75.0)	65.0 (59.0–70.0)	<0.001
BMI	23.7 (21.6–25.6)	23.7 (21.7–25.7)	23.7 (21.6–25.4)	0.229
Pre-ECMO transfer	1,244 (24.3%)	937 (24.9%)	307 (22.5%)	0.078
Pre-ECMO cardiac arrest	1,307 (25.5%)	1,010 (26.9%)	297 (21.7%)	<0.001
Pre-ECMO diagnosis				<0.001
Myocarditis	585 (11.4%)	558 (14.8%)	27 (2.0%)	
Post-cardiotomy shock	611 (11.9%)	452 (12.0%)	159 (11.6%)	
Acute myocardial infarction	1,204 (23.5%)	794 (21.1%)	410 (30.0%)	
Chronic heart failure	21 (0.4%)	16 (0.43%)	5 (0.37%)	
Sepsis	284 (5.5%)	211 (5.6%)	73 (5.3%)	
Other	2,422 (47.2%)	1,730 (46.0%)	692 (50.7%)	
Medical history				
Cardiac surgery	376 (7.3%)	280 (7.4%)	96 (7.0%)	0.656
Cardiac intervention	766 (14.9%)	502 (13.3%)	264 (19.3%)	<0.001
Myocardial infarction	657 (12.8%)	416 (11.1%)	241 (17.6%)	<0.001
Hypertension	1,999 (39.0%)	1,227 (32.6%)	772 (56.5%)	<0.001
Diabetes	1,037 (20.2%)	631 (16.8%)	406 (29.7%)	<0.001
Hyperlipidemia	612 (11.9%)	399 (10.6%)	213 (15.6%)	<0.001
Heart failure	794 (15.5%)	539 (14.3%)	255 (18.7%)	<0.001
Nervous system dysfunction	311 (6.1%)	157 (4.2%)	154 (11.3%)	<0.001
Chronic respiratory disease	259 (5.1%)	156 (4.1%)	103 (7.5%)	<0.001
Chronic kidney disease	162 (3.2%)	112 (3.0%)	50 (3.7%)	0.467
Anticoagulants	569 (11.1%)	354 (9.4%)	215 (15.7%)	<0.001
Smoking	1,574 (30.7%)	1,169 (31.1%)	405 (29.6%)	0.342
Cirrhosis	49 (1.0%)	40 (1.1%)	9 (0.7%)	0.248
Pre-ECMO hemodynamics				
Heart rate (rpm)	114.0(80.0–139.0)	118.0 (82.0–140.0)	105.0 (70.0–131.0)	<0.001
SBP (mm Hg)	75.0 (60.0–89.0)	75.0 (60.0–89.0)	75.0 (60.2–90.0)	0.470
DBP (mm Hg)	45.0 (35.0–56.0)	45.0 (35.0–56.0)	45.0 (35.0–56.0)	0.593
MAP (mm Hg)	55.0 (45.0–66.7)	55.0 (45.0–66.7)	55.0 (45.0–66.7)	0.989
EF (%)	40.0 (28.0–55.0)	38.0 (27.0–54.0)	44.0 (30.0–56.0)	<0.001
Pre-ECMO blood gases				
PH	7.3 (7.2–7.4)	7.3 (7.2–7.4)	7.3 (7.2–7.4)	0.771
HCO3 (mmol/L)	19.0 (14.9–23.0)	19.0 (15.0–23.0)	19.0 (14.6–23.2)	0.723
PO2 (mm Hg)	78.0 (59.0–123.0)	79.0 (59.1–122.1)	77.2 (59.0–124.0)	0.464
PCO2 (mm Hg)	37.7 (30.0–47.1)	38.0 (30.0–47.8)	37.0 (29.5–46.3)	0.253
Lactate (mmol/L)	6.9 (3.1–12.3)	6.7 (3.0–12.0)	7.6 (3.4–13.0)	0.028
SaO2 (%)	95.0 (85.7–99.0)	95.0 (85.0–99.0)	95.0(87.0–99.0)	0.503
Pre-ECMO support				
Mechanical ventilation	4,065 (79.3%)	3,016 (80.2%)	1,049 (76.8%)	0.009
Type of vasopressors				0.003
0	1,677 (32.7%)	484 (35.4%)	1,193 (31.7%)	
1	1,149 (22.4%)	273 (20.0%)	876 (23.3%)	
2	1,230 (24.0%)	302 (22.1%)	928 (24.7%)	
3	1,071 (20.9%)	307 (22.5%)	764 (20.3%)	
Large center	2,202 (42.9%)	1,501 (39.9%)	701 (51.3%)	<0.001

Data are presented as median (interquartile range) or n (%). Type of vasopressors, the number of different types of vasopressors used. Pre-ECMO hemodynamics and blood gases, the worst hemodynamic and laboratory values within the 6 hours before ECMO initiation. Large center, center with more than 30 cases annually.

BMI, body mass index; DBP, diastolic blood pressure; ECMO, extracorporeal membrane oxygenation; EF, ejection fraction; MAP, mean arterial pressure; SBP, systolic blood pressure.

demonstrated a significant age-related increase in mortality risk (adjusted odds ratio [adj OR]: 1.02, 95% confidence interval [CI]: 1.01–1.02, $p < 0.001$). When stratified by age, patients aged 46–64 years showed the highest risk of mortality (adj OR: 1.04, 95% CI: 1.02–1.06, $p < 0.001$), while patients aged 65–74 years and ≥75 years did not show statistically significant differences in mortality (adj OR: 1.02, 95% CI: 0.96–1.08, $p = 0.559$ and adj OR: 0.97, 95% CI: 0.89–1.05, $p = 0.403$, respectively) (Table 3). Regarding successful ECMO weaning, the odds of successful weaning decreased slightly with age, with the 46–64 years age group showing a significantly lower likelihood of successful weaning (adj OR: 0.95, 95% CI: 0.93–0.98, $p < 0.001$). No significant difference in weaning success was observed for the 65–74 years (adj OR: 1.00, 95% CI: 0.93–1.07, $p = 0.955$) and ≥75 years (adj OR: 1.05, 95% CI: 0.96–1.15, $p = 0.289$) groups (Table 3). The baseline characteristics indicated that patients in the 46–55 age group exhibited significantly higher rates of pre-ECMO CA and pre-ECMO transfer, along with more frequent diagnoses of myocarditis and sepsis before ECMO initiation. In addition, these patients presented with lower pre-ECMO SBP, reduced EF, lower pH values, and fewer cases receiving ECMO in large centers, all with p values <0.05 (Supplemental Table 1, Supplemental Digital Content, http://links.lww.com/

Table 2. Outcomes Between the Two Groups

Outcomes	Overall (N = 5,127)	Young Group (N = 3,761)	Elder Group (N = 1,366)	p Value
In-hospital mortality	2,415 (47.1%)	1,697 (45.1%)	718 (52.6%)	<0.001
Weaned from ECMO	4,007 (78.2%)	2,986 (79.4%)	1,021 (74.7%)	<0.001
30 day survival	2,925 (57.1%)	2,224 (59.1%)	701 (51.3%)	<0.001
Complications				
Mechanical	214 (4.2%)	153 (4.1%)	61 (4.5%)	0.582
Bleeding	879 (17.1%)	658 (17.5%)	221 (16.2%)	0.287
Neurologic	242 (4.7%)	177 (4.7%)	65 (4.8%)	0.997
Renal	2,413 (47.1%)	1,792 (47.6%)	621 (45.5%)	0.176
Pulmonary	1,360 (26.5%)	1,005 (26.7%)	355 (26.0%)	0.624
Metabolic	2,081 (40.6%)	1,510 (40.1%)	571 (41.8%)	0.302
Limb	375 (7.3%)	272 (7.2%)	103 (7.5%)	0.754

Data are presented as n (%).

ECMO, extracorporeal membrane oxygenation.

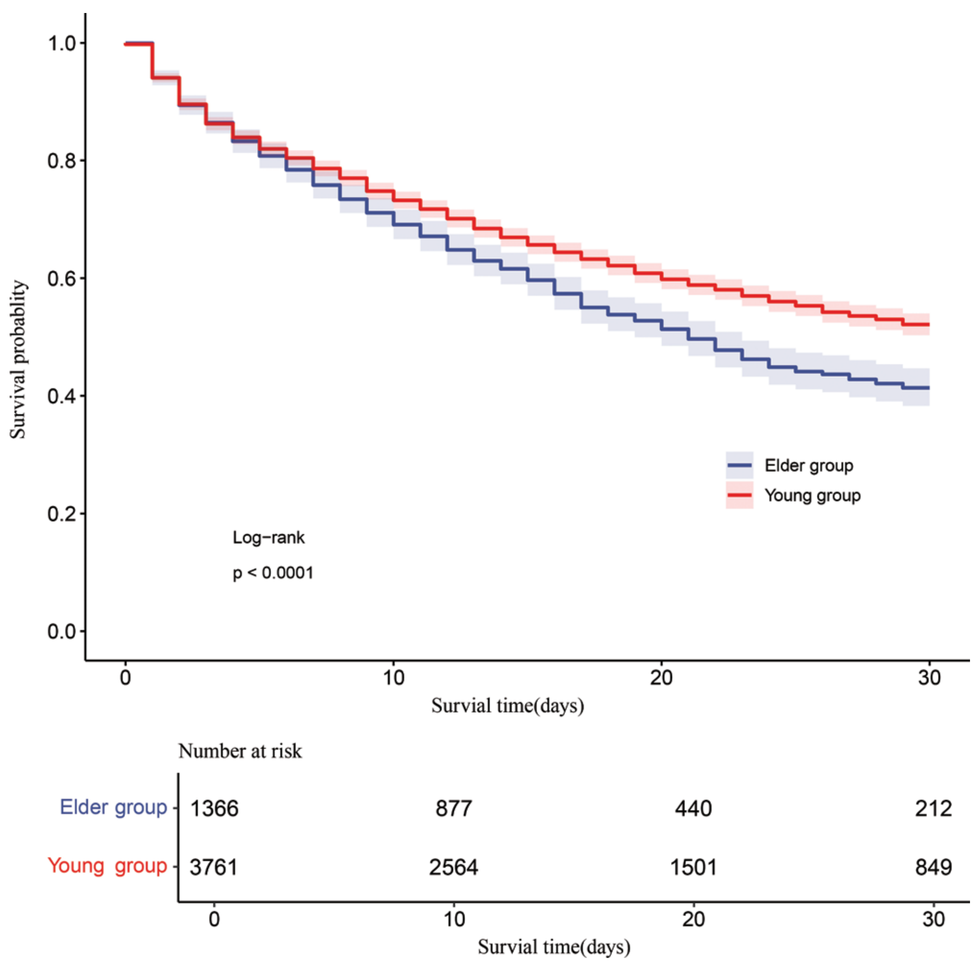

Figure 3. The curve of survival between the two groups.

ASAIO/B433). While the 46–55 age group had a lower in-hospital mortality rate compared with the 56–64 age group (45.1% *vs*. 48.7%, $p = 0.083$), the difference was not statistically significant. However, this group exhibited a significantly higher rate of successful weaning from ECMO (81% *vs*. 77.4%, $p = 0.042$) (Supplemental Table 2, Supplemental Digital Content, http://links.lww.com/ASAIO/B434). Logistic regression analysis further demonstrated that patients aged 46–55 had a significantly higher risk of weaning difficulty (adj OR: 0.88, 95% CI: 0.82–0.94, $p < 0.001$). Although the analysis suggested a higher risk of in-hospital mortality (adj OR: 1.04, 95% CI: 0.99–1.09, $p = 0.090$), with no statistical significance (Supplemental Table 3, Supplemental Digital Content, http://links.lww.com/ASAIO/B435). Further correlation analysis of age, gender, and 30 day survival revealed a nonlinear relationship. Specifically, there was a lower risk of death up to 56 years of age, with a progressively higher risk of death thereafter. Gender-stratified analysis showed that the

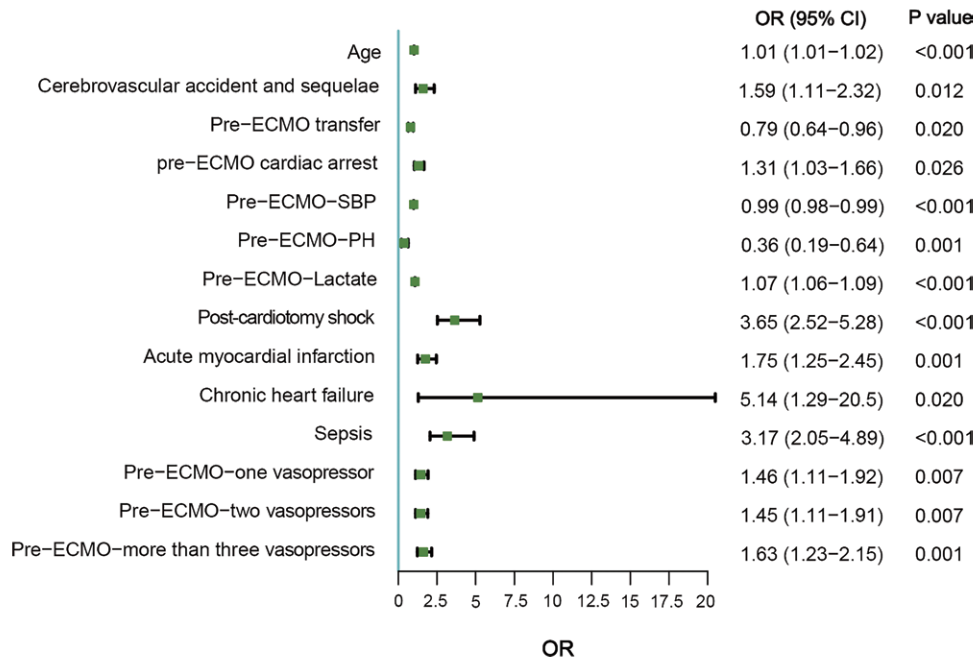

Figure 4. Multifactorial logistic regression analysis. CI, confidence interval; ECMO, extracorporeal membrane oxygenation; OR, odds ratio; SBP, systolic blood pressure.

risk of death for females lagged behind that of males, with a progressively higher risk for females observed after the age of 60 years (Figure 5).

Discussion

The main findings of this clinical study indicate a rising number of young VA-ECMO cases from 2017 to 2019, followed by a decline from 2020 to 2023. Overall, the young group exhibited superior survival outcomes compared with older patients. Specifically, in-hospital mortality was significantly lower in the young group compared with elderly patients, with the most significant effects observed in middle-aged patients, particularly those aged 46–64 years. The relationship between increasing age and in-hospital death was found to be nonlinear and varied by gender.

From 2009 to 2022, the Extracorporeal Life Support Organization (ELSO) registry recorded 154,568 ECMO runs, with approximately 50% of adult patients supported by VA-ECMO in 2022.[8] Lorusso *et al.*[5] observed a substantial increase in VA-ECMO cases over the decade leading up to 2015, noting a higher incidence among older patients (≥75 years) compared with younger patients (<75 years). In this study, the number of cases involving younger patients exceeded those of older patients until 2020, after which it gradually declined relative to older patient cases. Despite providing circulatory and pulmonary support, VA-ECMO is associated with significant risks of death and severe complications.[5,9,10] However, the overall survival rate in our study improved to 52.9% from 2017 to 2022. Similar findings have been reported in the ELSO registry and various national registries, as well as in single and multicenter studies.[11–15] Specifically, young patients in our study exhibited a higher survival rate, which was attributed to having fewer comorbidities compared with older patients. Previous studies have often considered advanced age as a potential contraindication for mechanical circulatory support due to anticipated poorer outcomes.[16–18] However, our study found that young patients experienced higher rates of bleeding complications, renal complications, and mechanical complications such as thrombosis within the ECMO circuit or hemolysis. These complications were more common among younger patients likely due to longer ECMO durations and a higher incidence of CA before ECMO implantation compared to elderly patients. Such conditions are known to increase the risk of severe complications.[9,19,20]

This study identified risk factors associated with in-hospital mortality in patients with CS requiring VA-ECMO, age, pre-ECMO CA, history of cerebrovascular disease, multiple types of vasopressors before ECMO, and elevated pre-ECMO lactate were identified as independent predictors of mortality in VA-ECMO patients. Similar findings have been reported by other authors, highlighting older age,[21,22] elevated lactate levels,[23] pre-ECMO CA,[22] history of cerebrovascular disease and its sequelae,[22] and high-dose vasoactive drug use,[24,25] as independent risk factors for death in VA-ECMO patients. In addition, pre-ECMO transfer and higher pre-ECMO SBP were identified as protective factors in this study. Contrary to some previous studies suggesting that age greater than 55 or 65 years may not be a negative predictor of poorer prognosis in VA-ECMO,[26–28] our findings indicate that increasing age was associated with in-hospital death, with a lower risk observed up to 56 years of age and a progressively higher risk thereafter. This nuanced finding underscores the importance of careful patient selection, even among younger patients. Although aggressive treatment strategies are often favored for young patients, clinicians should consider the overall clinical context when deciding on ECMO application, as not all young patients necessarily experience favorable outcomes.

Table 3. Logistic Analysis in the Subgroup Among Age and Outcomes

		In-Hospital Mortality			Weaning From ECMO		
Variables	Number (%)	Adj OR (95% CI)	*p*	*p* for Interaction	Adj OR (95% CI)	*p*	*p* for Interaction
All patients	5,127 (100.00)	1.02 (1.01–1.02)	<0.001		0.99 (0.98–0.99)	<0.001	
Gender				0.159			0.572
Male	3,608 (70.37)	1.01 (1.01–1.02)	<0.001		0.98 (0.98–0.99)	<0.001	
Female	1,519 (29.63)	1.02 (1.01–1.03)	<0.001		0.99 (0.98–1.00)	0.009	
Young				0.485			0.865
Age >65 years	1,366 (26.64)	1.01 (0.98–1.03)	0.631		0.99 (0.96–1.02)	0.379	
Age ≤65 years	3,761 (73.36)	1.02 (1.01–1.03)	<0.001		0.99 (0.98–0.99)	0.002	
Age (years)				0.065			0.005
18–45	1,295 (25.26)	1.00 (0.98–1.02)	0.753		1.01 (0.99–1.03)	0.433	
46–64	2,466 (48.10)	1.04 (1.02–1.06)	<0.001		0.95 (0.93–0.98)	<0.001	
65–74	1,041 (20.30)	1.02 (0.96–1.08)	0.559		1.00 (0.93–1.07)	0.955	
≥75	325 (6.34)	0.97 (0.89–1.05)	0.403		1.05 (0.96–1.15)	0.289	
BMI				0.716			0.506
<24	2,777 (54.16)	1.02 (1.01–1.02)	<0.001		0.99 (0.98–0.99)	<0.001	
≥24	2,350 (45.84)	1.02 (1.01–1.03)	<0.001		0.98 (0.97–0.99)	<0.001	
Myocarditis				0.459			0.467
No	4,542 (88.59)	1.01 (1.00–1.02)	<0.001		0.99 (0.98–1.00)	<0.001	
Yes	585 (11.41)	1.02 (1.00–1.04)	0.055		0.99 (0.96–1.01)	0.266	
Postcardiotomy shock				0.827			0.389
No	4,516 (88.08)	1.02 (1.01–1.02)	<0.001		0.99 (0.98–0.99)	<0.001	
Yes	611 (11.92)	1.02 (1.00–1.04)	0.027		0.98 (0.96–1.00)	0.017	
Acute myocardial infarction				0.765			0.959
No	3,923 (76.52)	1.02 (1.01–1.03)	<0.001		0.98 (0.98–0.99)	<0.001	
Yes	1,204 (23.48)	1.02 (1.00–1.03)	0.022		0.98 (0.97–1.00)	0.074	
Chronic heart failure				0.136			0.285
No	5,106 (99.59)	1.02 (1.01–1.02)	<0.001		0.99 (0.98–0.99)	<0.001	
Yes	21 (0.41)	15.33 (0.00–Inf)	1.000		0.29 (0.00–Inf)	1.000	
Sepsis				0.786			0.937
No	4,843 (94.46)	1.02 (1.01–1.02)	<0.001		0.99 (0.98–0.99)	<0.001	
Yes	284 (5.54)	1.03 (1.00–1.05)	0.054		0.99 (0.96–1.01)	0.312	
Large center				0.278			0.674
No	2,886 (56.72)	1.02 (1.01–1.02)	<0.001		0.99 (0.98–0.99)	<0.001	
Yes	2,202 (43.28)	1.01 (1.01–1.02)	0.001		0.99 (0.98–1.00)	0.018	
Pre-ECMO transfer				0.441			0.674
No	3,883 (75.74)	1.02 (1.01–1.02)	<0.001		0.99 (0.98–0.99)	<0.001	
Yes	1,244 (24.26)	1.02 (1.01–1.03)	<0.001		0.98 (0.97–1.00)	0.015	
Pre-ECMO cardiac arrest				0.433			0.472
No	3,820 (74.51)	1.02 (1.01–1.03)	<0.001		0.98 (0.98–0.99)	<0.001	
Yes	1,307 (25.49)	1.01 (1.00–1.02)	0.008		0.99 (0.98–1.00)	0.025	

Large center, center with more than 30 cases annually. OR adjusted by gender, age, body mass index, pre-ECMO PH (the worst laboratory values within the 6 hours before ECMO initiation), pre-ECMO lactate (the worst laboratory values within the 6 hours before ECMO initiation), medical history, and pre-ECMO cardiac arrest.

CI, confidence interval; ECMO, extracorporeal membrane oxygenation; OR, odds ratio.

Limitation

The CSECLS registry used in this study was limited to data collected during hospitalization without follow-up after discharge. Retrospectively collected data were susceptible to incomplete or missing events, although complete information regarding death outcomes was available, some variables had missing data. This potential for missing data could introduce bias into the study results; however, the large size of the database and its comprehensive approach helped mitigate this bias. Diagnosing complications may have been prone to misdiagnosis or incorrect categorization, potentially leading to an underestimation of complication incidence. In addition, information regarding events after transfer to other hospitals was unavailable, which might have underestimated the final outcomes. One of the major limitations of this study is the lack of long-term survival data, particularly 1-year survival, which would provide a more comprehensive assessment of patient outcomes after VA-ECMO for CS. Our analysis focused on in-hospital mortality, which, while important, may not fully capture the long-term benefits or risks of VA-ECMO treatment. Future studies with extended follow-up periods are needed to evaluate the durability of VA-ECMO interventions and the long-term survival of patients.

Conclusions

This study found that young patients undergoing VA-ECMO for CS generally experience better outcomes compared with older patients. Although many young patients would need to receive aggressive ECMO interventions, careful patient selection can help mitigate the common complications associated with this treatment.

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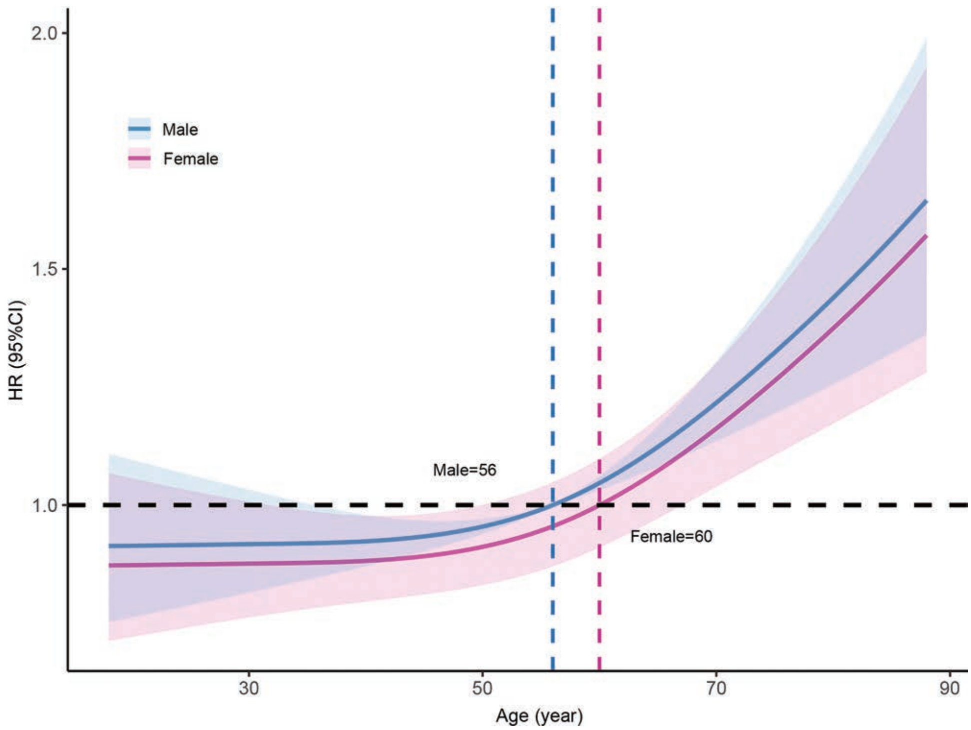

Figure 5. The restricted cubic splines. CI, confidence interval; HR, hazard ratio.

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