



# Factors Affecting Mortality in Extracorporeal Membrane Oxygenation: A Single-Center Retrospective Analysis

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## ABSTRACT

**Objectives:** This study aimed to evaluate the clinical, demographic, and process-related factors affecting in-hospital mortality among patients undergoing extracorporeal membrane oxygenation (ECMO).

**Methods:** This single-center retrospective study included data from a total of 279 patients (233 adults and 46 pediatric patients) who underwent ECMO between 01 January 2014 and 31 December 2023. Patient demographics, ECMO indications, ECMO configurations, sites and timing of ECMO initiation, duration of ECMO support, and clinical outcomes were analyzed. A p value <0.05 was considered statistically significant.

**Results:** The most common indication for ECMO was post-cardiotomy failure (36.5%), followed by COVID-19-related acute respiratory failure (26%). Veno-arterial ECMO was the most frequently used configuration in both adult and pediatric patients, whereas veno-venous ECMO was associated with the longest duration of support. Pediatric patients demonstrated significantly higher ECMO weaning and hospital discharge rates than adults.

**Conclusion:** Pediatric patients receiving ECMO showed higher rates of successful weaning and hospital discharge compared with adults. While patient age and ECMO indication were significant determinants of mortality, ECMO configuration, timing, and site of initiation were not independently associated with mortality or weaning success.

**Keywords:** Extracorporeal membrane oxygenation, mortality, survival

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## Introduction

Extracorporeal membrane oxygenation (ECMO) is an advanced life-support therapy used in patients with severe cardiac and/or respiratory failure who are unresponsive to conventional medical and mechanical support. By providing temporary extracorporeal circulation and gas exchange, ECMO enables cardiac and pulmonary recovery while preserving end-organ function. Despite advances in ECMO technology and growing clinical experience, mortality rates remain high, and clinical outcomes vary substantially.

Previous studies have demonstrated that pre-ECMO clinical status, duration of ECMO support, and the presence of organ dysfunction are important predictors of mortality in both adult and pediatric populations.<sup>[1-5]</sup> The indications for ECMO have expanded considerably over the past decade, encompassing postcardiotomy cardiac failure, cardiogenic shock, and, more recently, coronavirus disease 2019 (COVID-19)-related acute respiratory failure. Although large registry-based analyses have provided important epidemiological insights, data comparing determinants of

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mortality between pediatric and adult ECMO populations within the same institutional setting remain limited.

Therefore, the primary outcome of this study was to evaluate factors associated with in-hospital mortality in pediatric and adult patients receiving ECMO support. Secondary outcomes included assessment of successful weaning from ECMO, duration of ECMO support, and the influence of ECMO indication, configuration, and initiation characteristics on clinical outcomes.

**Methods**

This single-center retrospective study analyzed prospectively recorded data from pediatric and adult patients who received ECMO support between 2014 and 2023. Ethical approval was obtained from the Ethics Committee (No: 30.04.2024-48), and the study was conducted in accordance with the Declaration of Helsinki, ensuring patient confidentiality and data anonymity.

All patients who underwent ECMO support during the study period and had complete, accessible medical records were included. Patients with incomplete or missing medical data were excluded from the study. Recorded clinical variables included age, sex, ECMO indication, presence of comorbidities, ECMO configuration (veno-venous [VV], veno-arterial [VA], or hybrid), timing and site of ECMO initiation, duration of ECMO support, successful weaning from ECMO, and in-hospital outcomes. The primary outcome was in-hospital mortality. Secondary outcomes included successful weaning from ECMO, duration of ECMO support, and the association of ECMO-related factors with clinical outcomes.

Successful weaning from ECMO was defined as survival for at least 24 hours following decannulation without the need for reinstitution of extracorporeal support.

Hospital discharge was defined as survival to discharge from the index hospitalization.

**Statistical Analysis**

Statistical analyses were performed using SPSS Statistics version 22 (IBM Corp., Armonk, NY, USA). Data normality

was assessed using the Kolmogorov–Smirnov test. Continuous variables were analyzed using Student’s t-test or one-way analysis of variance (ANOVA) for normally distributed data and the Mann–Whitney U test for non-normally distributed data. Categorical variables were analyzed using the chi-square test. Relationships between continuous variables were evaluated using Spearman correlation analysis, and logistic regression analysis was performed when appropriate. A p-value <0.05 was considered statistically significant.

**Results**

A total of 288 pediatric and adult patients who received ECMO support were initially evaluated. Nine patients with incomplete or unavailable data were excluded, resulting in a final cohort of 279 patients, including 233 adults (83.5%) and 46 pediatric patients (16.5%). Demographic characteristics and ECMO indications are presented in Tables 1 and 2. Post-cardiotomy failure was the most common indication for ECMO across all patients (36.6%), followed by COVID-19–related acute respiratory failure.

**Mortality Analysis**

Overall, pediatric patients demonstrated lower in-hospital mortality compared with adults. Mortality differed according to ECMO indication, whereas ECMO configuration, timing of initiation, and site of initiation were not significantly associated with mortality in either group (p>0.05).

**Weaning Analysis**

The overall mean duration of ECMO support was 6.9 days. Pediatric patients had a longer mean duration of ECMO support compared with adults (9.9 days vs. 6.5 days). Successful weaning from ECMO occurred in 45.7% of pediatric patients and 23.6% of adult patients, with a significantly higher weaning rate observed in the pediatric group (p=0.003) (Table 3). The highest weaning success rates were observed in adult patients with cardiogenic

**Table 1. Age distribution and sex characteristics of pediatric and adult patients undergoing ECMO**

	n	Age min-max (Mean±SD)	p	Gender	n	Age (Mean±SD)	p
Pediatric group	46	1–18 (4.8±5.7)	p>0.05	Female	22	4.8±5.6	0.972
				Male	24	4.8±6.0	
Adult group	233	19–88 (52.6±14.6)	p>0.05	Female	83	51.6±16.6	0.420
				Male	150	53.2±13.5	

Data are presented as mean±SD and number (%). p values indicate comparisons between sexes within each age group. ECMO: Extracorporeal membrane oxygenation; SD: Standard deviation

**Table 2.** Distribution of ECMO indications in adult and pediatric patients

	Total		Adult group		Pediatric group	
	n	%	n	%	n	%
Post-cardiac surgery failure	102	36.56	74	31.8	28	60.9
Cardiogenic shock	27	9.68	24	10.3	3	6.5
ARDS	21	7.53	18	7.7	3	6.5
Pneumonia	4	1.43	4	1.7	0	0
Bridge to lung transplant	12	4.30	12	(5.2	0	0
Pulmonary embolism	25	8.97	24	10.3	1	2.2
Sepsis	6	2.16	5	2.1	1	2.2
Drug intoxication	3	1.07	3	(1.3	0	0
Covid-19 related ARF	73	26.16	69	29.6	4	8.7
Miyocarditis	3	1.07	0	0	3	6.5
Diaphragmatic hernia	3	1.07	0	0	3	6.5
Total	279	100.0	233	100.0	46	100.0

The table presents the distribution of primary ECMO indications in adult and pediatric patient groups. Indications are reported as number of patients (n) and percentage within each group. ARDS: Acute Respiratuar Distres Sendrome; ARF: Acute Respiratory Failure; Covid-19: Corona virus disease-19

**Table 3.** Comparison of successful ECMO weaning rates between pediatric and adult patients

		Pediatric		Adult		Total		p
		n	%	n	%	n	%	
Weaning	No	25	54.3	178	76.4	203	72.8	0.003*
	Yes	21	45.7	55	23.6	76	27.2	
Total		46	100.0	233	100.0	279	100.0	

\*:  $p < 0.005$  Fisher Exact test. The rate of successful ECMO weaning was 45.7% in pediatric patients and 23.6% in adult patients. The difference between groups was statistically significant (Fisher's exact test,  $p = 0.003$ ). ECMO: Extracorporeal membrane oxygenation

shock and in pediatric patients with COVID-19-related acute respiratory failure. Pediatric patients receiving ECMO for post-cardiotomy failure also showed higher weaning success compared with adults (Table 4).

No statistically significant association was identified between the presence of comorbidities, ECMO duration, successful weaning, and overall clinical outcomes ( $p > 0.05$ ). However, adult patients who were successfully weaned from ECMO had significantly longer durations of ECMO support compared with those who were not weaned ( $p = 0.001$ ). Similarly, adult patients without comorbidities received significantly longer ECMO support than those with comorbidities ( $p = 0.001$ ) (Table 5, 6). Furthermore, adult patients who required intra-aortic balloon pump (IABP) support prior to ECMO initiation demonstrated significantly lower rates of successful ECMO weaning ( $p = 0.02$ ) (Table 7).

### ECMO-Related Factors

VA-ECMO was the most frequently used configuration in both groups and was particularly predominant in pediatric

**Table 4.** Successful ECMO weaning rates in pediatric patients according to underlying indication.

ECMO indications	Weaning			
	Pediatric group		Adult group	
	n	%	n	%
Post-cardiac surgery failure	13	46.4	8	10.8
Cardiogenic shock	1	33.3	11	45.8
ARDS	1	33.3	6	33.3
Pneumonia	0)	0.0	1	25
Bridge to transplantation	0	0.0	3	25
Pulmonary embolism	0	0.0	5	20.8
Sepsis	0	0.0	2	40
Drug intoxication	0	0.0	0	0.0
Covid-19 related ARF	3	75	29	27.5
Miyocardit	2	66.7	1	33.3
Diaphragmatic hernia	1	33.3	0	0.0

The highest successful weaning rate in pediatric patients was observed in COVID-19-related acute respiratory failure (75%), whereas in adult patients the highest rate was observed in cardiogenic shock (45.8%). ARDS: Acute respiratory distress syndrome, ARF: Acute Respiratory Failure; Covid-19: Corona virus disease-19

**Table 5.** Association between ECMO support duration and successful weaning in adult patients

Weaning	n	ECMO duration (mean ranks)	U	p
No	178	107.5	3.210	0.001*
Yes	55	147.6		

\*: Mann Whitney U test. The relationship between ECMO support duration and successful weaning was analyzed using the Mann–Whitney U test. The mean rank was 147.6 in successfully weaned patients and 107.5 in non-weaned patients (U=3210, p=0.001). ECMO: Extracorporeal membrane oxygenation

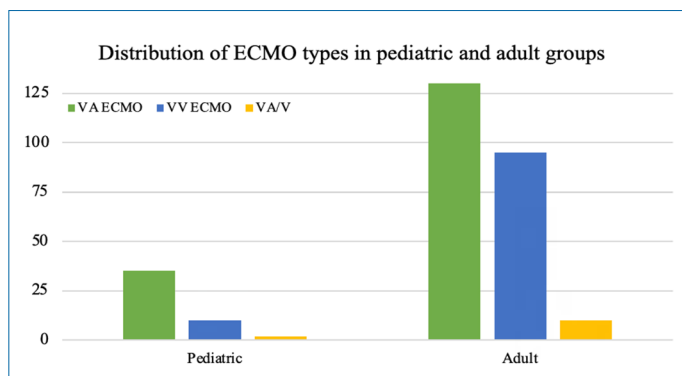
**Table 6.** Association between comorbidity status and ECMO support duration in adult patients

Comorbidity	n	ECMO duration (mean ranks)	U	p
No	113	131.8	5.106	0.001*
Yes	120	103.1		

\*: Mann Whitney U test. The relationship between comorbidity status and ECMO support duration was analyzed using the Mann–Whitney U test. The mean rank was 131.8 in patients without comorbidities and 103.1 in patients with comorbidities (U=5106, p=0.001).

patients (73.9%). (Fig. 1) VV-ECMO was associated with the longest duration of support in both groups, whereas VA-ECMO had shorter support durations, especially in adults (Fig. 2).

ECMO was most commonly initiated in the intensive care unit (59.13%); however, no significant association was found between the site of ECMO initiation and weaning success or mortality (p>0.05). Similarly, no statistically significant difference was identified between pediatric and adult groups with respect to weekday versus weekend ECMO initiation (p=0.051). Although ECMO was predominantly initiated on weekdays, the timing of initiation was not significantly associated with either



**Figure 1.** Distribution of ECMO configurations in pediatric and adult patients.

The chart shows the number of patients according to ECMO configuration (VA, VV, and VA/V) in pediatric and adult groups. ECMO: Extracorporeal membrane oxygenation; VA: Veno-arterial; VV: Veno-venous.

**Table 7.** Association between pre-ECMO intra-aortic balloon pump (IABP) support and successful weaning in adult patients

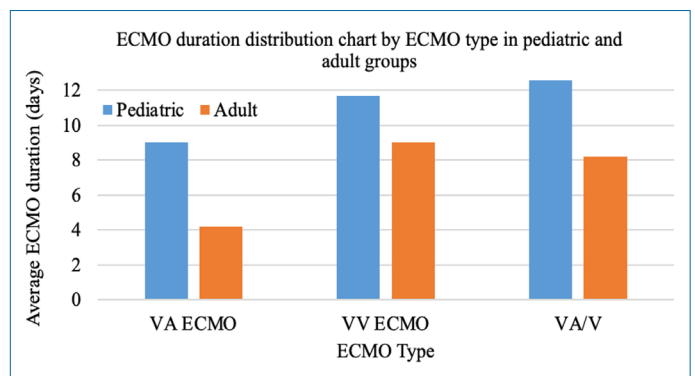
		Pre-ECMO				p
		Without IABP		With IABP		
		n	%	n	%	
Successful weaning from ECMO	No	128	71.9	50	28.1	0.02*
	Yes	48	87.3	7	12.7	
Total		176	75.5	57	24.5	

\*: p<.005 Fisher Exact test. The relationship between pre-ECMO IABP support and successful ECMO weaning was evaluated using Fisher’s exact test. The successful weaning rate was 87.3% in patients without prior IABP support and 12.7% in those who received IABP support before ECMO initiation (p=0.02). ECMO: Extracorporeal membrane oxygenation

weaning success or mortality in either group (p>0.05). Post-ECMO clinical outcomes in both pediatric and adult groups are summarized in Table 8. Among the 76 patients successfully weaned from ECMO, 41 patients (53.9%) were discharged from the hospital, while the remaining patients experienced in-hospital mortality or were referred to other centers.

### Discussion

In the present study, pediatric patients demonstrated significantly higher rates of successful ECMO weaning and hospital discharge compared with adult patients. Consistent with our findings, data from the ELSO Registry indicate that pediatric patients generally have a higher potential for clinical recovery and a faster response to ECMO support.<sup>[1]</sup> In contrast, the higher burden of comorbidities in adult patients and the more frequent use of ECMO in advanced and less reversible clinical conditions may negatively influence outcomes. Consistent with our findings, previous reports have indicated that



**Figure 2.** Mean ECMO support duration according to ECMO configuration in pediatric and adult patients.

The chart illustrates the average duration of ECMO support (days) by ECMO type (VA, VV, and VA/V) in pediatric and adult groups. ECMO: Extracorporeal membrane oxygenation; VA: Veno-arterial; VV: Veno-venous.

**Table 8.** Clinical outcome following ECMO in pediatric and adult groups

Clinical outcome for all patients				Clinical outcomes of patients in groups after ECMO				
Discharge n (%)	Exitus n (%)	Refferral n (%)	Total n(%)		Discharge n (%)	Exitus n (%)	Refferral n (%)	Total n (%)
41 (53.9)	34 (44.7)	1 (1.3)	76 (100.0)	Pediatric group	13 (61.9)	8 (38.1)	0	21 (100.0)
				Adult group	28 (50.9)	26 (47.3)	1 (1.8)	55 (100.0)

Post-ECMO clinical outcomes are summarized for pediatric and adult patients. Among the 76 patients successfully weaned from ECMO, 41 (53.9%) were discharged, one patient (1.3%) was transferred to another center, and mortality after successful weaning was observed in 34 patients (44.7%)

postcardiotomy cardiogenic shock is among the leading indications for ECMO support in adult patients.<sup>[2-4]</sup> Similarly, large-scale cohort studies have demonstrated that ECMO support is predominantly utilized in adult populations, which parallels the distribution observed in our study.<sup>[5-7]</sup>

Makdisi et al.<sup>[8]</sup> emphasized that the relationship between ECMO configuration and mortality is more closely associated with the underlying indication and patient physiology rather than the ECMO configuration itself, which is consistent with our findings demonstrating no direct association between ECMO modality and mortality outcomes. Schmidt et al.<sup>[9]</sup> reported that VV-ECMO is generally used in cases of respiratory failure requiring prolonged support, whereas VA-ECMO is applied for shorter durations in acute cardiac decompensation.

In our study, the highest rate of successful ECMO weaning was observed among patients in whom ECMO was initiated in the intensive care unit (ICU). According to ELSO Registry data, the rate of successful weaning in patients who undergo ECMO initiation in the ICU ranges between 30% and 35%.<sup>[11]</sup>

In contrast to our findings showing no significant association between ECMO initiation site and clinical outcomes, Zou et al.<sup>[10]</sup> reported higher survival and weaning rates in patients who received intraoperative ECMO compared with postoperative initiation, suggesting that differences in patient selection and clinical context may explain the variability among studies.

In a recent cohort analysis, nighttime and weekend VA-ECMO cannulation were not identified as independent predictors of increased one-year mortality. Similarly, in our study, the timing of ECMO initiation (weekday versus weekend) was not significantly associated with mortality outcomes, supporting the absence of a clinically relevant "weekend effect" in experienced centers.<sup>[11]</sup>

Although patients with comorbidities tended to require longer durations of ECMO support in our study, this difference did not reach statistical significance. Similarly, Chandel et al.<sup>[12]</sup> reported that the presence of comorbidities may act as an indirect factor prolonging treatment

duration rather than serving as a direct determinant of ECMO-related mortality. However, several studies have shown that the need for pre-ECMO mechanical circulatory support, such as intra-aortic balloon pump (IABP), reflects more severe underlying cardiac dysfunction and is associated with significantly higher mortality rates, consistent with our findings.<sup>[13,14]</sup>

Several limitations of this study should be acknowledged. Its single-center, retrospective design may have resulted in heterogeneous patient selection and reliance on data with variable clinical detail. Additionally, temporal changes in ECMO teams, clinical protocols, and technological advancements may have influenced treatment strategies and outcomes. Another important limitation is the lack of consistently available baseline clinical severity scores, as well as detailed pre-ECMO hemodynamic and laboratory parameters, which were not consistently available in the dataset. Therefore, adjustment for initial disease severity could not be performed, which represents an important limitation when interpreting mortality outcomes.

## Conclusion

In this retrospective study, pediatric patients receiving ECMO demonstrated higher rates of successful weaning and hospital discharge compared with adult patients. While patient age and ECMO indication appeared to be key determinants of mortality, ECMO configuration, timing of initiation, and site of cannulation were not found to have a direct significant impact on mortality or successful weaning from ECMO. Although the presence of comorbidities and duration of ECMO were not directly associated with mortality, the requirement for pre-ECMO mechanical circulatory support was related to a more unfavorable clinical course.

These findings suggest that clinical success in ECMO management is driven primarily by appropriate patient selection, accurate indication, and timely initiation of support rather than technical preferences. ECMO therefore represents an effective life-support strategy with high survival potential, particularly in pediatric patients.

## Disclosures

**Ethics Committee Approval:** The study was approved by the Marmara University Health Sciences Institute Ethics Committee (no: 48, date: 30/04/2024).

**Informed Consent:** Informed consent was obtained from all participants.

**Conflict of Interest Statement:** The authors declare that there is no conflict of interest.

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