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Neurological outcomes and quality of life in post-cardiac arrest patients with return of spontaneous circulation supported by ECMO

A retrospective case series

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Abstract

Post-cardiac arrest brain injury constitutes a significant contributor to morbidity and mortality, leading to cognitive impairment and subsequent disability. Individuals within this patient cohort grapple with uncertainty regarding the potential advantages of extracorporeal life support (ECMO) cannulation. This study elucidates the neurological outcomes and quality of life of post-cardiac arrest patients who attained spontaneous circulation and underwent ECMO cannulation. This is a retrospective case study within a local context, the research involved 32 patients who received ECMO support following an intrahospital cardiac arrest with return of spontaneous circulation (ROSC). An additional 32 patients experienced cardiac arrest with ROSC before undergoing cannulation. The average age was 41 years, with the primary causes of cardiac arrest identified as acute coronary syndrome (46.8%), pulmonary thromboembolism (21.88%), and hypoxemia (18.7%). The most prevalent arrest rhythm was asystole (37.5%), followed by ventricular fibrillation (34.4%). The mean SOFA score was 7 points (IQR 6.5–9), APACHE II score was 12 (IQR 9–16), RESP score was −1 (IQR −1 to −4) in cases of respiratory ECMO, and SAVE score was −3 (IQR −5 to 2) in cases of cardiac ECMO. Overall survival was 71%, and at 6 months, the Barthel score was 75 points, modified Rankin score was 2, cerebral performance categories score was 1, and the SF-12 had an average score of 30. Notably, there were no significant associations between the time, cause, or rhythm of cardiac arrest and neurological outcomes. Importantly, cardiac arrest is not a contraindication for ECMO cannulation. A meticulous assessment of candidates who have achieved spontaneous circulation after cardiac arrest, considering the absence of early signs of poor neurological prognosis, is crucial in patient selection. Larger prospective studies are warranted to validate and extend these findings.

Abbreviations: CPC = Cerebral Performance Categories Score, CPR = cardiopulmonary resuscitation, ECMO = extracorporeal membrane oxygenation, ECPR = extracorporeal cardiopulmonary resuscitation, IQR = interquartile range, ROSC = return of spontaneous circulation, VA = Venoarterial, VV = Venovenous.

Keywords: cardiac arrest, extracorporeal membrane oxygenation (ECMO), neurological outcomes, quality of life

1. Introduction

Patients who are critically ill, particularly those in groups with cardiogenic shock and refractory hypoxemia, face a higher likelihood of experiencing cardiac arrest.[1] Among those who achieve return of spontaneous circulation (ROSC), a post-cardiac arrest syndrome may manifest, characterized by myocardial injury, systemic inflammatory response due to reperfusion, multiorgan dysfunction, and ischemic brain injury.[2] The survival rate in these cases ranges from 15% to 22%.[1,3] Importantly, secondary brain injury from cerebral ischemia is the primary cause of morbidity, with a significant risk of cognitive impairment and disability affecting approximately 28.1% of patients who survive the acute phase.[3]

Extracorporeal membrane oxygenation (ECMO) support has been proposed as a rescue strategy in cases of cardiogenic shock

The authors declare that the present study did not have competing interests.

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

The study was approved by the local ethics committee (Comité de Ética Fundación Clínica Shaio) under number DIB-23-36. The ethics committee waived the need for informed consent considering the retrospective nature of data collected. We declare that this manuscript collects honestly, accurately and transparently the information relative to the study that reports, there are no financial or personal relationships with other people or organizations that could inappropriately bias our work.

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and refractory hypoxemia, offering a means to ensure adequate oxygen supply and limit the progression of organ failure.[4,5] Contraindications for ECMO initiation include significant central nervous system impairment or irreversible and incapacitating neurological pathology.[4] However, in post-cardiac arrest patients, determining these conditions during the acute phase can be challenging due to the absence of poor prognostic signs and the inability to conduct complementary tests given the patient instability.[6]

Predictive scales such as SAVE (Survival After Veno-arterial ECMO) and RESP (Respiratory ECMO survival prediction) consider cardiac arrest as a factor that worsens patient prognosis but not as an absolute contraindication for cannulation.[7,8] Despite recent evidence demonstrating favorable vital and neurological outcomes,[9–11] decisions regarding ECMO can be controversial due to uncertainties surrounding neurological prognosis.

In this study, we assessed the neurological outcomes and quality of life in patients who experienced cardiac arrest with return of spontaneous circulation and were supported with ECMO.

2. Methodology

A retrospective case series was conducted on patients who experienced cardiac arrest with return of spontaneous circulation (ROSC) and received ECMO support at the intensive care unit of Fundación Clínica Shaio in Bogotá, Colombia during the period from January 1, 2020, to December 1, 2022. Patients aged 18 years and older who experienced cardiac arrest with return of spontaneous circulation (ROSC) and required ECMO support due to refractory shock and/or refractory hypoxemia were included, those with incomplete medical records were excluded from the study.

Six months after the patients' discharge, survivors were contacted via telephone, and standardized interviews were conducted using the Rankin Scale, Barthel Index, Cerebral Performance Categories Score (CPC), and SF-12 quality of life survey. Data were collected through the institutional REDCAP® registry with approval from the institutional ethics and research committee. The sample was described using descriptive statistical tools. For continuous variables, measures of central tendency and dispersion were calculated. Central tendency measures include the mean, median, and mode, while dispersion measures include the range, standard deviation, and variance.

For qualitative variables, the distributions of absolute and relative frequencies were calculated. Absolute frequencies represent the number of occurrences of each category, while relative frequencies express the proportion of each category relative to the total sample. Additionally, statistical graphs were constructed to illustrate the behavior of the variables visually.

3. Results

3.1. Population

A total of 210 patients were cannulated with ECMO during the period from January 2020 to December 2022. Among them, 32 patients received ECMO support after experiencing an intrahospital cardiac arrest with return of spontaneous circulation (ROSC). Of these patients, 18 (56.25%) were male, with an average age of 41 years (range: 14.9), and an average body mass index of 27.73 kg/m² (range: 5.58). The most common comorbidity was diabetes mellitus, present in 31.25% of the patients, followed by systemic arterial hypertension, dyslipidemia, and smoking in 12.5% each.

The severity scores at the time of cannulation showed a mean SOFA Score of 7 points (interquartile range (IQR: 6.5–9), APACHE II Score of 12 points (IQR: 9–16), RESP Score of -1 point (IQR: –1 to –4) for patients on respiratory ECMO, and SAVE Score of -3 points (IQR: –5 to 2) for patients on cardiac ECMO. The main indication for cannulation in the majority of patients was cardiogenic shock, observed in 23 cases (71.8%), followed by hypoxemia in 8 cases (25%) and septic shock in 1 patient (1%). The average duration of VA ECMO support was 7.6 days, while VV ECMO was 4.2 days. The overall survival rate was 71.8% (23 patients). The average length of stay in the ICU was 21 days (IQR: 11.08–33.70), with an average duration of mechanical ventilation of 15.87 days (IQR: 14–21.01) and a hospital stay of 38 days (IQR: 25–53). The main complications observed were major bleeding, cardiovascular events, and renal complications, each occurring in 25% of cases. Major bleeding was the most frequent complication in deceased patients, affecting 55.56% of the cases (Table 1).

3.2. Cause of cardiac arrest

The main causes of cardiac arrest was acute coronary syndrome in 15 patients (46.8%), followed by pulmonary thromboembolism in 7 patients (21.8%), hypoxemia in 6 patients (18.7%), pneumothorax in 3 patients (9.38%), and hyperkalemia in 1 patient (3.13%). Among those cases, 3 patients (9.3%) were diagnosed with COVID 19. Regarding the most frequent rhythms observed during cardiac arrest, asystole was present in 12 patients (37.5%), followed by ventricular fibrillation in 11 patients (34.3%), pulseless electrical activity in 6 patients (18.7%), and ventricular tachycardia in 3 patients (9.3%). The average duration of cardiac arrest was 10.12 minutes (range: 5.65), while for survivors, the average time was 11.30 minutes (range: 5.99) (Table 2).

3.3. Neurological outcomes

Out of the total sample, 23 patients successfully underwent decannulation and survived until discharge. During the 6-month follow-up, the neurological outcomes were assessed using the Cerebral Performance Categories Score, which had a median score of 1 (IQR: 1–2), indicating good cerebral performance. The functional status, measured by the Barthel Index, had a median score of 75 points (IQR: 60–100), indicating moderate to high levels of independence in activities of daily living. The modified Rankin Scale, used to assess disability, had a median score of 2 points (IQR: 1–2.5), indicating a relatively low level of disability. Additionally, the SF-12 quality of life survey had a median score of 30 (IQR: 27–31), suggesting a relatively good quality of life for these patients. Importantly, there were no significant differences observed between patients who received ECMO VA and ECMO VV support in terms of neurological outcomes and quality of life (Table 3).

During the administration of the SF-12 questionnaire, it was found that 42.8% (n = 6) of the participants rated their health as very good, followed by 21.4% (n = 3) who considered it good and fair. On the other hand, 50% (n = 7) of the surveyed individuals stated that their current health did not limit them from engaging in moderate efforts, while 64.2% (n = 9) indicated that they did not experience limitations in their daily or work activities and that they did not reduce their level of physical activity in the last 4 weeks compared to what they would like to do.

Regarding questions about the impact of emotional problems, it was observed that 50% (n = 7) of the surveyed individuals reported a reduction in their desired activities due to emotional issues, while 57% (n = 8) stated that they did not perform their usual work or daily activities due to an emotional problem. Concerning pain and its impact on regular work, 35.7% (n = 5) reported having little pain, 28.5% (n = 4) described it as moderate, and 14.2% (n = 2) experienced quite a bit of pain. During the last 4 weeks, 64% (n = 9) of the respondents mostly felt

Table 1

Demographic characteristics of patients received ECMO support after experiencing an intrahospital cardiac arrest with ROSC.

Variable	Patients n = 32	Dead = 9	Alive = 23	*P* value
Age in yr, median (SD)	41.38 (14.93)	41.65 (14.73)	41.27 (15.33)	.948
Male, n (%)	18 (56.25%)	4 (44.44%)	14 (60.87%)	.434
Body mass weight median (SD)	27.73 (5.58)	27.81 (5.02)	27.7 (5.89)	.956
Intensive care stay (days) - M (IQR)	21.09 (11.08–33.70)	6.21 (4–16)	24.83 (14.81–40.67)	.05*
Mechanical ventilation (days)- M (IQR)	14.59 (8.03–18.92)	9.07 (4.46–14.1)	15.87 (14–21.01)	.039*
Hospital stay (days)- M (IQR)	29 (16–43)	15 (4–23)	38 (25–53)	<.001*
Comorbidities', n (%)				
Diabetes mellitus	10 (31.25%)	1 (11.11%)	23 (39.13%)	.124
Arterial hypertension	4 (12.5%)		4 (17.39%)	.181
Hypothiroidism	3 (9.38%)		3 (13.04%)	.255
Coronary disease	1 (3.13%)		1 (4.35%)	.525
Dyslipidemia	4 (12.5%)		4 (17.39%)	.181
Atrial fibrilation	1 (3.13%)		1 (4.35%)	.525
Obesity	8 (25%)	3 (33.33%)	5 (21.74%)	.496
Heart failure	1 (3.13%)		1 (4.35%)	.525
Indication for ECMO n(%)				.253
Pulmonary thromboembolism	7 (21.88%)	1 (11.11%)	6 (26.09%)	
ARDS not COVID 19	6 (18.75%)	3 (33.33%)	3 (13.04%)	
ARDS COVID 19	3 (9.3%)	1 (11.1%)	2 (8.6%)	
Arrhythmic storm	3 (9.38%)	1 (11.11%)	2 (8.7%)	
Coronary syndrome	10 (31.25%)	2 (22.22%)	8 (34.78%)	
Postcardiotomy	2 (6.25%)	1 (11.11%)	1 (4.35%)	
Heart failure	1 (3.13%)	0	1 (4.35%)	
Type of support, n (%)				.284
Venovenous ECMO	9 (28.13%)	4 (44.44%)	5 (21.74%)	
Venoarterial ECMO	23 (71.87%)	5 (55.55%)	18 (78.26%)	
Severity score (IQR)				
SOFA Score	7 (6.5–9)	7 (6–9)	9 (7–10)	.348
APACHE II Score	12 (9–16)	12 (9–15)	12 (8–18)	.691
Oxygen debt, DEOx	35.86 (9.92–77.44)	35.5 (12.69–74.78)	36.22 (2.86–80.98)	.738
RESP	´–1 (–1 a –4)	´–1 (–3 a 1)	´–1 (–4 a –1)	.573
SAVE	´–3 (–5 a 2)	´–4 (–4 a –2)	´–3 (–5 a 3)	.393
Complications n (%)				
Mechanical complication	4 (12.5%)	1 (11.11%)	3 (13.04%)	.882
Mayor bleeding	8 (25%)	5 (55.56%)	3 (13.04%)	.013*
Neurological complication	5 (15.63%)	2 (22.22%)	3 (13.04%)	.520
Cardiovascular	8 (25%)	3 (33.33%)	5 (21.74%)	.496
Renal complications	8 (25%)	1 (11.11%)	7 (30.43%)	.256

APACHE = acute physiology and chronic health disease classification system, ECMO = Extracorporeal membrane oxygenation, IQR = intercuartile range, M = median, SD = standar deviation, SOFA = Sequential organ failure assessment.

*$P < .05$.

Table 2

Cause and rhythm of cardiac arrest.

Variable	Patients n = 32	VA n = 23	VV n = 9	*P* value
Cardiac arrest time (min) M (SD)	10.12 (5.65)	10.9 (5.9)	8.1 (4.6)	.915
Cause of cardiac arrest, n (%)				.003*
Hypoxemia	6 (18.75%)	1 (4.35)	5 (56.6)	
Pneumothorax	3 (9.38%)	1 (4.35)	2 (22.2)	
Pulmonary embolism	7 (21.88%)	6 (26.1)	1 (11.1)	
Acute coronary syndrome	15 (46.88%)	14 (60.9)	1 (11.1)	
Hyperkalemia	1 (3.13%)	1 (4.35)		
Rhythm of cardiac arrest, n(%)				.091
Asystole	12 (37.5%)	9 (39.1)	3 (33.3)	
Pulseless electrical activity	6 (18.75%)	2 (8.7)	4 (44.4)	
Ventricular fibrillation	11 (34.38%)	10 (43.5)	1 (11.1)	
Ventricular tachycardia	3 (9.38%)	2 (8.7)	1 (11.1)	

M = median, SD = Standard deviation.

*$P < 0.05$.

calm and tranquil. 35.7% (n = 5) indicated that they had a lot of energy most of the time, while in some moments, they felt discouraged and sad. Additionally, 35.7% (n = 5) reported that at times, their physical or emotional health problems made social activities difficult.

4. Discussion

Patients who experience cardiac arrest with return of spontaneous circulation (ROSC) and require ECMO support present a challenging situation. They need extracorporeal support to ensure adequate oxygenation and tissue perfusion, stabilize

Table 3

Neurological outcomes.

Variable	Patients = 23	VA n = 18	VV n = 5	*P* value
Cerebral performance categories score, M (IQR)	1 (1–2)	1 (1–2)	2 (1–2)	.197
Barthel Score, M (IQR)	75 (60–100)	85 (60–100)	70 (60–70)	.812
Modified Rankin Score, M (IQR)	2 (1–2.5)	2 (1–2)	2 (2–3)	.185
SF-12 Score, M (IQR)	30 (27–31)	30 (28–31)	24 (24)	NA

IQR = interquartile range, M = Median.

*$P < .05$.

their underlying condition, and prevent the progression of multiple organ dysfunction. However, the limitation in establishing short and medium-term neurological prognosis immediately after ROSC can make the decision to initiate ECMO controversial. The lack of sufficient studies to determine the neurological outcomes and quality of life benefits further adds to the complexity of the decision-making process.

The use of ECMO-assisted resuscitation (ECPR) has shown significant growth in recent years, leading to improved survival rates and better neurological outcomes in post-cardiac arrest patients. This improvement is attributed to the limitation of hypoperfusion and enhanced organ perfusion, which helps mitigate the damage associated with the post-cardiac arrest syndrome.[12–14] Studies, such as the one conducted by Shin TG et al, have demonstrated that in cases of intrahospital cardiac arrest, patients treated with ECPR had a 23.5% survival rate with minimal neurological impairment compared to 5.9% in patients treated with conventional CPR at the 2-year follow-up.[14] While the benefits of extracorporeal support in patients undergoing ECPR are evident, the same clarity does not extend to patients who experienced cardiac arrest with return of spontaneous circulation (ROSC) before ECMO cannulation. The impact of ECMO support on neurological outcomes and quality of life in these patients remains uncertain.

In our study, among the 32 patients who were cannulated, we observed an overall survival rate of 71.8%. When analyzing the specific types of ECMO support, the survival rate for ECMO V-V was 21.7%, while for ECMO V-A, it was 78.2%. Comparing these results with previous studies, we found that the survival rate for ECMO V-V in our population was lower than the study by Bhardwaj et al, which reported a survival rate of 57% for post-cardiac arrest patients on ECMO VV.[9] On the other hand, our survival rate for ECMO V-A was higher compared to the study by Chonde et al, which reported a survival rate of 46.7% in a similar group of patients.[15] Considering that the cardiac arrest in our study was intrahospital and the average duration of cardiac arrest was 10.12 minutes (range: 5.65), the overall survival rate of 71.8% is relatively high. These results suggest that ECMO support has shown promising outcomes in our patient population, considering the challenging nature of intrahospital cardiac arrests and the duration of the arrest.

The neurological outcomes observed at 6 months were favorable, with a CPC score of 1 (1–2), Barthel Index score of 75 (60–100), and modified Rankin Scale score of 2 (1–2.5). In the study by Bhardwaj et al, which included 21 adult patients with intra and extrahospital cardiac arrest with RCE who were cannulated with ECMO VV for refractory hypoxemia, no specific neurological outcomes were reported.[9] Chonde et al evaluated 51 patients with cardiac arrest, of which 36 (70.5%) received ECPR and 15 (29.4%) were cannulated after RCE. Among them, 72.5% of the patients underwent hypothermia treatment. The survival rate was higher in patients with a motor response before cannulation, but there were no specific data on neurological outcomes.[15] De Chambrun found that 27% of the survivors cannulated with ECMO V-A after cardiac arrest with RCE had a CPC score of 1 at the 1-year follow-up.[10] In the study by Bougouin et al, which included 52 patients with cardiogenic shock who experienced cardiac arrest and RCE and were cannulated with ECMO VA, the survival rate was 25%, and most patients had a CPC score of 1 to 2 at hospital discharge, which is similar to the data found in our study.[11]

The international consensus on cardiopulmonary resuscitation (ILCOR) has identified several factors associated with improved survival and neurological outcomes after cardiac arrest. These factors include the presence of witnesses, a short duration of cardiopulmonary resuscitation (CPR), a shockable rhythm and early identification of the cause of the cardiac arrest.[16,17] These factors were consistent with the findings in your study, where the cardiac arrest occurred in an intrahospital setting, had a short duration, and the most common rhythm observed was ventricular fibrillation. At the International Symposium of the European Society of Anesthesiology (ESA), determinants of neurological prognosis were identified, such as the time elapsed from cardiac arrest to the initiation of CPR, the duration of hypoperfusion (low cardiac output during resuscitation), and the quality of CPR.[18] Unfortunately, these specific data were not available in our study.

The impact of cardiac arrest and ECMO support on patients' quality of life goes beyond physical recovery and often involves psychological and emotional aspects. In our study, we found that the main complaints from patients regarding their quality of life were related to emotional issues, particularly depression and anxiety. This highlights the importance of addressing the mental and emotional well-being of patients from the time they are in the intensive care unit (ICU) and throughout their recovery journey. The findings from Hatch et al's prospective study in the UK reinforce this concern, as they found that a significant proportion of ICU survivors experienced anxiety (46%), depression (40%), and post-traumatic stress disorder (22%) primarily during the first 2 years after discharge.[19] Furthermore, Shannon et al's study in 2022 involving ECMO survivors reported that a considerable number of patients (37%) were diagnosed with new mental disorders, with depression, anxiety, and post-traumatic stress being the most prevalent.[20] This highlights the need for increased attention to the psychological well-being of ECMO patients to improve their overall quality of life and optimize their long-term recovery. Integrating psychological care as part of the holistic approach to ECMO support can lead to better outcomes and improved quality of life for these patients.

The study has several limitations that should be considered when interpreting the results. Firstly, the sample size is relatively small, and the study design is retrospective in nature. This could limit the generalizability of the findings to a larger population. However, it is worth noting that this study appears to be the first of its kind to specifically evaluate neurological outcomes in patients who underwent ECMO cannulation after cardiac arrest. Another important limitation is that the patients in the study did not receive therapeutic hypothermia, a strategy known to potentially improve neurological outcomes in post-cardiac arrest patients. The absence of therapeutic hypothermia in the treatment protocol might have influenced the neurological outcomes observed in the study.

5. Conclusion

In our study, 32 patients post cardiac arrest who return of spontaneous circulation and underwent ECMO cannulation were included. We analyzed survival, neurological outcomes, and quality of life, observing a 71.8% survival rate with favorable neurological and quality of life outcomes. Cardiac arrest is not a contraindication for ECMO cannulation, a comprehensive assessment of candidates who have achieved spontaneous circulation following cardiac arrest, considering the absence of early signs of poor neurological prognosis, is crucial when selecting patients.

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