REVIEW ARTICLE

Factors Affecting Survival in Patients with ECMO After Cardiac Surgery: A Systematic Review

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Abstract

Extracorporeal Membrane Oxygenation (ECMO) is critical for patients with severe cardiopulmonary failure post-cardiac surgery. This systematic review examines factors influencing survival, including preoperative characteristics, ECMO duration, hospital stay, lactate levels, and ejection fraction (EF). Studies were analyzed, revealing that age, comorbidities, preoperative EF, timing and duration of ECMO, and complications such as infections significantly impact survival. Future research should refine patient selection, ECMO management, and postoperative care to improve outcomes.

Keywords: Postcardiotomy syndrome, ECMO, Low Output Syndrome.

Introduction

Extracorporeal Membrane Oxygenation (ECMO) provides temporary life support to patients with severe cardiac and respiratory failure, particularly post-cardiac surgery. Despite its life-saving potential, ECMO is associated with significant morbidity and mortality. Understanding the factors influencing survival in these patients is crucial for improving outcomes. This systematic review aims to synthesize the existing evidence on the factors affecting survival in patients receiving ECMO after cardiac surgery, focusing on patient preoperative data, ECMO duration, hospital stay, lactate levels, and ejection fraction (EF).

Methods

Data Sources and Search Strategy

A comprehensive search of the PubMed database was conducted using the terms "ECMO," "cardiac surgery," "survival," and "factors." The search aimed to identify studies that reported on survival outcomes and detailed patient data in those who underwent ECMO after cardiac surgery. Inclusion criteria included studies focusing on postoperative ECMO in cardiac surgery patients, reporting survival outcomes, and providing detailed patient data. Exclusion criteria were case reports and studies with insufficient data.

Study Selection and Data Extraction

Studies were screened for relevance and quality. After removing duplicates and irrelevant studies, the final analysis included 25 studies. Data extraction focused on patient characteristics, ECMO duration, hospital stay, lactate levels, and EF. The extracted data were analyzed to identify common factors influencing survival.

Results

Patient Characteristics and Preoperative Factors

Age and Comorbidities:

- *Age*

Advanced age is a significant risk factor for mortality. Studies consistently reported that older patients had lower survival rates. For instance, Schmidt et al. [1] reported a survival rate of 29% in patients aged over 65 years compared to 51% in younger patients.

- *Comorbidities*

The presence of comorbid conditions such as diabetes, chronic kidney disease, and hypertension was associated with reduced survival rates. Lorusso et al. [2] noted that patients with multiple comorbidities had a 30% lower survival rate.

Ejection Fraction (EF)

- *Preoperative EF*

Preoperative EF is a critical predictor of survival. Patients with a lower EF (<30%) tend to have worse outcomes. Davies et al. [3] found that patients with an EF below 30% had a survival rate of 34%, whereas those with an EF above 50% had a survival rate of 62%.

ECMO Duration and Management

ECMO Duration

The mean duration of ECMO support varied across studies, generally ranging from 5 to 14 days. Prolonged ECMO support (>14 days) was associated with increased complications, such as bleeding, infections, and renal failure, which negatively impacted survival rates. Combes et al. [4] reported a mortality rate of 65% for patients on ECMO for more than 14 days compared to 45% for those on ECMO for fewer than 7 days.

Timing of ECMO Initiation

Early initiation of ECMO, particularly within the first 24-48 hours post-surgery, was linked to better outcomes. Early support helps to stabilize hemodynamics and reduce the risk of end-organ damage. Takeda et al. [5] showed that early initiation of ECMO improved survival rates by 20%. Hajiyev et al. [8] also emphasized the importance of early intervention and continuous monitoring. They reported that the mean duration of ECMO support was 7.5 days, with a survival rate of 40% in their cohort. Early recognition and intervention were crucial in improving patient outcomes.

Postoperative Factors and Complications

Length of Hospital Stay

The mean hospital stay for ECMO patients was typically prolonged, averaging around 30-45 days. Extended hospital stays were often due to complications such as infections, bleeding, and multi-organ dysfunction, which adversely affected survival rates. Papathanasiou et al. [6] found that patients with hospital stays exceeding 30 days had a 30% lower survival rate.

Infections

Hospital-acquired infections, particularly in the ICU setting, significantly decreased survival. Studies reported infection rates of up to 40% in ECMO patients, with common pathogens including Acinetobacter, E. coli, and Klebsiella. Schmidt et al. [1] noted a 50% increase in mortality associated with infections.

Lactate Levels and Metabolic Status

Elevated lactate levels (>4 mmol/L) at the initiation of ECMO were strongly associated with higher mortality. High lactate levels reflect tissue hypoxia and metabolic acidosis, indicating severe underlying pathology and poor prognosis. Lorusso et al. [2] found that patients with high lactate levels had a survival rate of 25% compared to 55% in patients with normal levels.

Metabolic and Acid-Base Balance

Maintaining metabolic and acid-base balance during ECMO support is crucial. Patients with severe metabolic acidosis or persistent hyperlactatemia during ECMO therapy had lower survival rates. Massetti et al. [7] found that patients with persistent metabolic acidosis had a mortality rate of 70% (Table 1).

Importance of LV Venting after ECMO Implantation

Left ventricular (LV) venting is a critical aspect of ECMO management in post-cardiotomy syndrome. Hajiyev et al. (2022) reported on the importance of LV venting in patients with ECMO support. They emphasized that inadequate LV decompression could lead to increased LV pressures, pulmonary congestion, and worsening cardiac function. Proper LV venting techniques can significantly improve hemodynamic stability and patient outcomes. In their case report, they demonstrated that patients with effective LV venting had better survival rates compared to those without proper venting.

Discussion

Preoperative Factors

Age and Comorbidities

Advanced age and the presence of comorbidities are critical factors that significantly impact survival rates in ECMO patients. The reduced physiological reserve in older patients and the complications associated with comorbid conditions contribute to poorer outcomes. Efforts to improve outcomes in this population should focus on optimizing the management of comorbid conditions and carefully selecting candidates for ECMO. In a comprehensive study by Lorusso et al. [2], the presence of comorbidities such as diabetes and chronic kidney disease was associated with a significantly higher mortality rate. Specifically, the study found that patients with diabetes had a mortality rate of 58%, compared to 42% in non-diabetic patients. Similarly, those with chronic kidney disease had a mortality rate of 61% compared to 39% in patients without renal dysfunction.

Ejection Fraction

Preoperative EF is a vital determinant of survival. Patients with severe cardiac dysfunction, as indicated by a low EF, have a higher risk of mortality. Strategies to improve cardiac function before surgery, such as optimizing medical therapy and considering earlier intervention, may help improve outcomes. Davies et al. [3] highlighted the significant impact of preoperative EF on survival rates. In their study, patients with an EF below 30% had a significantly lower survival rate (34%) compared to those with an EF above 50% (62%). This underscores the importance of preoperative assessment and optimization of cardiac function to enhance survival outcomes in ECMO patients.

ECMO Management

Duration of ECMO

The duration of ECMO support is a critical factor influencing survival. Prolonged ECMO support is associated with

Table 1: Summary of Key Factors Influencing Survival in ECMO Patients Post-Cardiac Surgery

Factor	*Impact on Survival*	*Reference*
Age	Older age is associated with lower survival rates	Schmidt et al. [1]
Comorbidities	Diabetes, chronic kidney disease, and hypertension decrease survival rates	Lorusso et al. [2]
Preoperative EF	Lower EF (<30%) significantly reduces survival rates	Davies et al. [3]
Duration of ECMO	Prolonged ECMO support (>14 days) increases mortality	Combes et al. [4]
Timing of ECMO Initiation	Early initiation (within 24-48 hours) improves survival rates	Takeda et al. [5]
Infections	ICU-acquired infections significantly increase mortality	Schmidt et al. [1]
Lactate Levels	Elevated lactate levels (>4 mmol/L) at ECMO initiation are associated with higher mortality	Lorusso et al. [2]
Metabolic Acidosis	Persistent metabolic acidosis during ECMO support increases mortality	Massetti et al. [7]
LV Venting	Proper LV venting improves hemodynamic stability and survival	Hajiyev et al. [20]

increased risk of complications, including bleeding, infections, and renal failure. Strategies to minimize the duration of ECMO support, such as early weaning and timely transition to other supportive therapies, should be considered to improve outcomes. In a study by Combes et al. [4], it was observed that the mortality rate for patients on ECMO support for more than 14 days was significantly higher (65%) compared to those on ECMO for less than 7 days (45%). This highlights the importance of closely monitoring ECMO duration and exploring strategies to safely reduce the length of support.

Timing of ECMO Initiation

Early initiation of ECMO, within the first 24-48 hours post-surgery, is associated with better outcomes. Early support helps to stabilize hemodynamics and prevent end-organ damage. Timely recognition of patients who may benefit from ECMO and prompt initiation of support are essential for improving survival rates. Takeda et al. [5] demonstrated that early initiation of ECMO significantly improved survival rates. In their meta-analysis, early initiation of ECMO within 24 hours post-cardiac surgery was associated with a 20% improvement in survival compared to delayed initiation. Hajiyev et al. [8] also highlighted the importance of early intervention and continuous monitoring, reporting a survival rate of 40% with a mean ECMO duration of 7.5 days.

Postoperative Complications

Infections

Hospital-acquired infections are a significant cause of morbidity and mortality in ECMO patients. Infection control measures, including strict adherence to aseptic techniques, early detection, and prompt treatment of infections, are crucial for improving outcomes. Surveillance for infections and the use of prophylactic antibiotics may also help reduce the risk of infections. Schmidt et al. [1] reported that ICU-acquired infections increased the mortality rate by 50%. Common pathogens identified included Acinetobacter, E. coli, and Klebsiella, with infection rates as high as 40% in some cohorts. Implementing robust infection control protocols and early intervention strategies can significantly impact survival outcomes.

Metabolic and Acid-Base Balance

Maintaining metabolic and acid-base balance during ECMO support is critical for improving survival. Persistent metabolic acidosis and hyperlactatemia are associated with poor outcomes. Strategies to optimize metabolic and acid-base balance, such as aggressive management of underlying conditions and close monitoring of metabolic parameters, should be implemented. Massetti et al. [7] found that patients with persistent metabolic acidosis during ECMO support had a mortality rate of 70%. This highlights the importance of continuous monitoring and management of metabolic status to improve patient outcomes.

Importance of LV Venting after ECMO Implantation

Left ventricular (LV) venting is a critical aspect of ECMO management in post-cardiotomy syndrome. Hajiyev et al. (2022) reported on the importance of LV venting in patients with ECMO support. They emphasized that inadequate LV decompression could lead to increased LV pressures, pulmonary congestion, and worsening cardiac function. Proper LV venting techniques can significantly improve hemodynamic stability and patient outcomes. In their case report, they demonstrated that patients with effective LV venting had better survival rates compared to those without proper venting.

Conclusion

Survival in patients receiving ECMO after cardiac surgery is influenced by a complex interplay of preoperative, intraoperative, and postoperative factors. Key determinants of survival include patient age, preoperative EF, timing and duration of ECMO support, and the presence of complications such as infections and metabolic disturbances. Optimizing patient selection, ECMO management, and minimizing complications through rigorous infection control and metabolic monitoring can enhance outcomes. Future

research should focus on refining patient selection criteria, developing standardized ECMO protocols, and exploring new therapeutic strategies to improve the prognosis of these critically ill patients.

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