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EXTRACORPOREAL MEMBRANE OXYGENATION (ECMO) IN CASES OF ACUTE CARDIORESPIRATORY FAILURE

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ABSTRACT
Acute cardiorespiratory failure is a critical condition that often requires advanced interventions, such as extracorporeal membrane oxygenation (ECMO). This method has stood out as an effective alternative for temporary support in cases refractory to conventional therapies, allowing hemodynamic stabilization and adequate oxygenation while awaiting recovery or considering definitive interventions. Thus, this study aimed to explore advances in the use of advanced cardiopulmonary bypass in cases of acute cardiorespiratory failure. To this end, an integrative literature review was carried out, the research question was elaborated based on the PICO strategy, namely: "What is the available evidence on the efficacy, indications, outcomes, and challenges related to the use of ECMO in patients with acute cardiorespiratory failure?" The inclusion criteria covered studies published between 2018 and 2024, in English, Portuguese and Spanish, that addressed the topic, presented relevant data and were available in full, while duplicate studies, not available in full, or that did not directly address the topic were excluded. The data sources consisted of widely recognized electronic databases, such as PubMed, LILACS, and SciELO. Through this, this study reviewed the recent literature to investigate the evidence related to the efficacy, indications, clinical outcomes, and challenges of ECMO in cases of acute cardiorespiratory failure. The analysis included 15 studies that explored different aspects of this technology, highlighting the need for rigorous patient selection criteria, early deployment, and well-trained multidisciplinary teams to optimize outcomes. The findings underscore the vital role of ECMO in critical situations, while pointing to the need for standardization of practices, development of more accessible technologies, and public policies that expand its availability. It is concluded that, although ECMO is a promising tool, its efficient application depends on an integrated approach that addresses the technical, ethical, and logistical challenges that the therapy still faces.

Keywords: Extracorporeal Membrane Oxygenation, Complications, Cardiopulmonary Circulation, Critical Care.

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INTRODUCTION

Acute cardiorespiratory failure is a serious clinical condition that represents one of the main causes of morbidity and mortality in critically ill patients, especially in contexts of failure of conventional methods of respiratory and circulatory support. Given the complexity and severity of this condition, extracorporeal membrane oxygenation (ECMO) has emerged as a revolutionary technology, offering temporary support while waiting for the recovery of compromised organs or considering definitive interventions, such as organ transplantation (Chaves; Ferreira; Santos 2019).

Historically, ECMO was developed to care for pediatric patients with severe respiratory failure, but in recent decades its use has expanded considerably, covering adults with refractory cardiorespiratory failure, with this advancement being driven by technological improvements in extracorporeal circuits, which now offer greater safety and efficiency, as well as better clinical outcomes in selected populations (Conitec 2021). Despite its relevance, advanced cardiopulmonary bypass remains a complex and high-cost therapy modality, generally restricted to referral centers with specialized teams (De Oliveira Filho; Alves; Souza 2024).

The applicability of cardiorespiratory support extracorporeal therapy in cases of acute cardiorespiratory failure is directly associated with its ability to temporarily replace pulmonary and cardiac functions, promoting adequate oxygenation and stable hemodynamics. In the study carried out by Josué Brito et al. (2024), it was shown that there is a positive impact on several conditions, such as acute respiratory distress syndrome (ARDS), cardiogenic shock, and serious complications associated with viral infections, including SARS-CoV-2.

The increasing use of therapy has also brought new ethical and logistical challenges, especially in resource-limited settings. The COVID-19 pandemic has highlighted these challenges, with an exponential increase in demand for extracorporeal support, revealing inequalities in access to this technology and raising questions about resource allocation in health crisis situations. In addition, the identification of reliable prognostic criteria for ECMO remains a critical research area (Lima da Cunha; Rodrigues da Costa 2022).

While ECMO has shown significant benefits in selected cases, the complexity of its deployment and maintenance requires a multidisciplinary approach. This includes the collaboration of intensivists, cardiovascular surgeons, perfusionists, and other health professionals. In addition, efficient control requires continuous training, clear protocols, and

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robust institutional support, reinforcing the need to develop specialized care networks (Ferro; Gomes; Birth 2021). In addition, this study aims to explore advances in the use of advanced cardiopulmonary bypass in cases of acute cardiorespiratory failure.

THEORETICAL FRAMEWORK

Acute cardiorespiratory failure is a condition that occurs when the respiratory and circulatory systems are unable to maintain adequate tissue oxygenation and perfusion. This condition can result from several causes, including acute respiratory distress syndrome (ARDS), cardiogenic shock, massive pulmonary embolism, and multiple organ failure (Chaves; Ferreira; Santos 2019). Clinical management traditionally involves advanced ventilatory and hemodynamic support, but in refractory cases, these strategies may be insufficient to prevent the progression of organ damage (Cavalcanti *et al*., 2021).

Extracorporeal Membrane Oxygenation (ECMO) emerges as a therapeutic modality for patients in critical situations in which conventional therapies fail. The basic principle of cardiorespiratory support extracorporeal therapy consists of removing the patient's venous blood, oxygenating it in an extracorporeal circuit, and returning it to the circulatory system. There are two main types of ECMO: veno-venous (VV), used predominantly for respiratory support, and veno-arterial (VV), applied in situations of cardiorespiratory support (Torres; Lee; Barbosa, 2021).

Technological advances in recent decades have improved the safety and efficacy of advanced cardiopulmonary bypass, allowing its application in a wider range of patients. The use of this resource has shown promise in cases of severe ARDS, especially in situations triggered by viral infections, such as influenza and SARS-CoV-2. In addition, patients with cardiogenic shock associated with acute myocardial infarction, fulminant myocarditis, or perioperative cardiac complications have benefited from extracorporeal support (Ferreira; Silva; Moraes, 2019).

However, the use of ECMO presents significant challenges. Complications, such as bleeding, thrombotic events, infections, and secondary organ dysfunction, are frequently reported, requiring continuous monitoring and multidisciplinary interventions. In addition, appropriate patient selection, based on clinical criteria and prognosis, is essential to maximize the benefits of this therapy. The timing of ECMO deployment is also a critical factor, as late interventions can reduce efficacy and increase mortality (Nakasato *et al*., 2020).

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The COVID-19 pandemic has highlighted the relevance of extracorporeal perfusion as an essential tool in the management of patients with severe respiratory failure. However, it also highlighted inequalities in access to this technology, due to its complexity, high costs, and the need for specialized teams. These factors raise ethical questions about the allocation of resources and the criteria for prioritizing patients, especially in situations of high demand (Melro; Silva; Alves 2024).

Implementing ECMO requires adequate infrastructure, specialized training, and well-established protocols. The multidisciplinary approach is key, integrating professionals such as intensivists, surgeons, perfusionists, and nurses to ensure effective management. In addition, the creation of referral networks for extracorporeal support is recommended to centralize resources and promote better clinical outcomes (Pereira; Andrade; Gomes 2021).

In view of this, cardiorespiratory support extracorporeal therapy represents a technology of great importance for the control of acute cardiorespiratory failure in critical contexts. However, to optimize its benefits, it is necessary to advance in the standardization of practices, the development of strategies to reduce complications, and the expansion of equitable access, considering its ethical and economic implications.

METHODOLOGY

This study is an integrative literature review, a method chosen due to its relevance in allowing the inclusion of different types of studies, enabling a comprehensive analysis of the efficacy, indications, outcomes, and challenges associated with the theme. The research question was elaborated based on the PICO strategy, being: "What is the available evidence on the efficacy, indications, outcomes, and challenges related to the use of ECMO in patients with acute cardiorespiratory failure?"

The inclusion criteria covered studies published between 2018 and 2024, in English, Portuguese and Spanish, that addressed the topic, presented relevant data and were available in full, while duplicate studies, not available in full, or that did not directly address the topic were excluded. The data sources consisted of widely recognized electronic databases, such as PubMed, LILACS, and SciELO. The search strategy used controlled descriptors and keywords related to the topic, such as "Extracorporeal Membrane Oxygenation", "Complications", "Cardiopulmonary Circulation" and "Critical Care", combined with Boolean operators to refine the results.

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The selection of studies was conducted in two stages: in the first, titles and abstracts were evaluated to determine their relevance in relation to the theme; in the second, the full texts of the selected articles were analyzed to confirm their eligibility. Two independent reviewers participated in this process, and disagreements were resolved by consensus or by the intervention of a third reviewer. The extracted data included information on study characteristics, inclusion and exclusion criteria used, results related to efficacy and clinical outcomes, as well as challenges and limitations pointed out by the authors.

The analysis and synthesis of the data followed a descriptive and critical approach, allowing the identification of patterns, gaps, and practical implications on the use of ECMO in acute cardiorespiratory failure. This approach was fundamental to organize the information into thematic categories that address the indications, benefits, complications, and technical and ethical challenges associated with therapy. Thus, the methodology adopted aimed to ensure scientific rigor.

RESULTS AND DISCUSSION

The results show the relevance of ECMO in the management of acute cardiorespiratory failure, based on 15 studies included after rigorous application of the inclusion and exclusion criteria. The analysis revealed that the studies addressed the main clinical, technical, and ethical aspects related to ECMO, highlighting its benefits, limitations, and challenges in clinical practice**.**

The included studies presented consistent evidence on the efficacy of ECMO in selected populations, especially in conditions such as acute respiratory distress syndrome (ARDS) and cardiogenic shock, a significant improvement in survival and clinical outcomes of patients treated with ECMO was observed, especially when implanted early (Salazar *et al.,* 2021). The study by Justino *et al.* (2022) highlights that the choice of the type of ECMO (veno-venous or veno-arterial) depends on the etiology of cardiorespiratory failure, with veno-venous preferring in cases of isolated lung failure and veno-arterial for circulatory support.

On the other hand, the review pointed out frequent complications associated with ECMO, such as hemorrhages, thrombotic events, nosocomial infections, and secondary organ dysfunctions. These events were attributed to the technical complexity of the therapy and the need for continuous anticoagulation during cardiopulmonary support (Nakasato; Lee; Lopes 2020; Leite *et al.,* 2024).

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Another aspect highlighted in the studies was the relevance of the COVID-19 pandemic, which significantly increased the demand for ECMO in cases of refractory severe respiratory failure (Pereira *et al.,* 2020). However, Meiro; Trinity; Park (2024) highlighted inequalities in access to ECMO, especially in low- and middle-income countries, due to high costs and the need for specialized infrastructure. In addition, ethical issues related to prioritizing patients in high-demand contexts were widely discussed.

Excluded studies were analysed for reasons for ineligibility, including lack of access to the full text, absence of specific data on ECMO, and methodological inconsistencies. Detailed data on the included and excluded studies, organised by databases, are presented in the table below:

Table 1: Distribution of Included and Excluded Studies by Databases

DATABASE	ARTICLES FOUND	EXCLUDED ITEMS	REASONS FOR EXCLUSION	INCLUDED ITEMS
PubMed	45	35	Lack of specific data on acute cardiorespiratory failure (15), outdated articles (10)	5
SciELO	30	25	Duplicate studies (12), lack of focus on ECMO (10), lack of relevant clinical data (8), other reasons (5)	10
LILACS	22	17	Focus on alternative therapies (8), lack of access to full text (5), insufficient data for analysis (4)	5
Total	97	**77**		**15**

Source: Researchers, 2024.

The data presented show that, despite technological and clinical advances, the use of ECMO still faces significant challenges. One of the main points of emphasis was the need for more precise criteria for the selection of patients (Filho *et al.,* 2024). Studies such as Oliveira; Silva; Nascimento (2022) emphasized that implementing rigorous protocols to assess ECMO eligibility can improve clinical outcomes and reduce complication rates. The lack of uniformity in these criteria between different centers was identified as a barrier to optimal application of the therapy.

Another critical point is the impact of deployment time. The analysis revealed that ECMO should be considered early, soon after the failure of conventional strategies, to increase the likelihood of success (Amorim *et al.,* 2024). Patients treated within 24 hours of diagnosis of cardiorespiratory failure had significantly higher survival rates compared with those undergoing delayed interventions. However, it is still noteworthy that this decision

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must be balanced with the risks of complications, such as severe hemorrhages and thrombotic events (Amorim et al., 2024; Pereira *et al.,* 2020).

Complications associated with ECMO, such as infections and secondary organ dysfunctions, remain a relevant challenge (Nakasato; Lee; Lopes 2020; Leite *et al.,* 2024). The need for continuous anticoagulation and the management of extracorporeal devices increase the risk of adverse events, especially in patients with multiple comorbidities. Strategies to reduce these complications include the use of more advanced technologies, such as membranes with anticoagulant properties and optimized circuitry to minimize vascular trauma (Leite *et al.,* 2024).

The COVID-19 pandemic has brought a new perspective on the use of ECMO, highlighting both its crucial role and limitations in health crisis situations. The exponential increase in demand has overwhelmed health systems, revealing inequalities in access to technology (Meiro; Trinity; Park 2024). Low- and middle-income countries faced additional difficulties, including shortages of equipment and trained professionals, which limited the adoption of ECMO in critical contexts. These factors have raised ethical debates about resource allocation and patient prioritization (Lorusso *et al.,* 2021).

The formation of reference networks for ECMO was widely discussed as a strategy to centralize resources and improve management efficiency. These networks would allow for the equitable distribution of patients among specialized centers, optimizing the use of equipment and trained staff. In addition, collaboration between different institutions could facilitate the standardization of protocols and the exchange of experiences, promoting better clinical outcomes (Bezerra *et al.,* 2022).

From an economic perspective, the high costs of ECMO remain a significant barrier. With this, it was suggested that the implementation of continuous training programs and the rationalization of the use of resources can help mitigate these costs (Lorusso *et al.,* 2021). In addition, public policies that promote the financing of highly complex health technologies are essential to expand access to ECMO in disadvantaged regions.

The importance of future research to address existing gaps was also noted. A highlighted priority was the development of more robust prognostic criteria that can guide patient selection and predict outcomes more accurately. In addition, investigations into new technologies, such as advanced monitoring systems and portable ECMO devices, can contribute to the evolution of therapy. Ethical issues related to the use of ECMO have been widely discussed, especially in resource-limited contexts. The prioritization of patients in

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high-demand situations, such as during the COVID-19 pandemic, has raised debates about equity in access to technology (Meiro; Trinity; Park 2024).

The psychological impact of ECMO on patients and families has also been addressed in some studies. Long-term extracorporeal support can generate significant emotional stress, both due to the severity of the condition and uncertainties about the outcomes. Psychological support and follow-up programs during and after therapy have been recommended as strategies to improve the quality of life of these individuals (Salazar *et al.,* 2021).

In addition, technological advances in ECMO have expanded its indications and clinical applications. Innovations such as more efficient circuitry, membranes with optimized properties and automated control systems have reduced complication rates and improved outcomes. However, the accessibility of these technologies is still limited in many countries, which reinforces the need for public policies that promote their dissemination (Pereira *et al.,* 2020).

The analysis also highlighted the importance of cost-effectiveness studies to assess the financial impact of ECMO on health systems. These studies can provide subsidies for the allocation of resources and the definition of priorities in public health. In addition, initiatives that encourage local production of ECMO equipment and materials can contribute to reducing costs and increasing the availability of therapy.

FINAL CONSIDERATIONS

The results of this review demonstrated that ECMO has been widely studied as an effective intervention for patients with acute cardiorespiratory failure in cases where other therapies have failed. The included studies provided robust evidence on its ability to improve clinical outcomes and provide temporary life support, especially when used early and in specialized centers. In addition, the analysis showed that while ECMO is a highly promising technology, challenges such as associated complications and inequalities in access still limit its large-scale application.

The limitations of this study include the selection restricted to publications in specific databases and in the period from 2018 to 2024, which may have excluded relevant studies outside this range. In addition, the methodological differences between the studies made it difficult to standardize the analyses, especially with regard to the criteria for inclusion of patients and management of complications.

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The findings fully met the research question, as they elucidated the available evidence on the efficacy, indications, and challenges of ECMO, as well as the clinical outcomes obtained in its application. However, the need for more standardized and comprehensive research, as well as policies that expand access to this technology, was clearly evidenced. Thus, this study contributes to reinforcing the importance of ECMO in the management of critically ill patients, while pointing to areas for improvement and future investigation.

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