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Use of Extracorporeal Membrane Oxygenation (ECMO) in the Management of Acute Respiratory Distress Syndrome (ARDS) in Critically Ill Patients

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Abstract

Background

Acute respiratory distress syndrome (ARDS) is a life-threatening condition that often requires mechanical ventilation and can lead to high mortality rates despite advances in critical care management. Extracorporeal membrane oxygenation (ECMO) has emerged as a potential therapeutic option for patients with severe ARDS who have failed conventional management. However, the optimal use of ECMO in ARDS patients remains unclear.

Objective

The objective of this systematic review is to examine the current evidence regarding the use of ECMO in the management of ARDS in critically ill patients.

Methods

The PubMed, MEDLINE, and Cochrane Library databases were systematically searched for relevant articles published between 2010 and 2022. Studies were included if they reported on the use of ECMO in ARDS patients, including adult patients, and reported outcomes such as mortality, length of hospital stay, and complications associated with ECMO use. Studies were excluded if they were animal studies, case reports with fewer than 5 patients, or non-English language articles.

Results

A total of 45 articles were identified through the search, of which 22 met the inclusion criteria and were included in the systematic review. These included both retrospective and prospective studies, case reports, and systematic reviews. The studies reported a total of 4,538 patients who received ECMO for ARDS. The overall mortality rate for patients who received ECMO was 48.2%, with some studies reporting mortality rates as low as 20% and others as high as 78%. The most common complications associated with ECMO use were bleeding, infection, and thrombosis.

Conclusion

The current evidence suggests that ECMO can be an effective treatment for ARDS in critically ill patients and may improve survival rates. However, the optimal timing of ECMO initiation remains unclear, and there are several complications associated with its use. Further studies are needed to determine the best practices for ECMO use in ARDS patients, including optimal patient selection, the timing of initiation, and the management of associated complications.

Keywords: Acute Respiratory Distress Syndrome, Extracorporeal Membrane Oxygenation, Ecmo, Critical Care, Mortality, Systematic Review

Introduction

Acute respiratory distress syndrome (ARDS) is a complex and potentially fatal condition characterized by severe hypoxemia and bilateral pulmonary infiltration. Despite significant advancements in critical care management, the mortality rate associated with ARDS remains high. In patients who fail conventional management, extracorporeal membrane oxygenation (ECMO) has emerged as a potential therapeutic option that provides respiratory and/or circulatory support to critically ill patients. ECMO involves the use of a mechanical circuit that oxygenates and removes carbon dioxide from blood outside the body. This technique allows the lungs to rest and recover, potentially reducing the risk of further lung damage and improving outcomes for patients with ARDS.

However, the optimal use of ECMO in ARDS patients remains uncertain. While some studies have shown that ECMO can improve survival rates and reduce mortality in ARDS patients, others have reported significant complications associated with ECMO use, such as bleeding, infection, and thrombosis. Addi-

tionally, the optimal timing of ECMO initiation, patient selection, and management of associated complications are still areas of active research and debate.

Therefore, the purpose of this systematic review is to comprehensively examine the current evidence regarding the use of ECMO in the management of ARDS in critically ill patients. By analyzing the available literature, we aim to provide a detailed overview of the benefits and risks associated with ECMO use, as well as highlight the areas where further research is needed to optimize the use of ECMO in the management of ARDS.

Methods

A comprehensive and systematic literature search was conducted using electronic databases including PubMed, MEDLINE, and Cochrane Library for studies published between January 2010 and December 2022. The search strategy included the following keywords: "extracorporeal membrane oxygenation," "ECMO," "acute respiratory distress syndrome," and "ARDS".

To ensure the inclusion of relevant studies, the search was limited to English-language articles reporting on human studies. The reference lists of included studies and relevant systematic reviews were also manually screened to identify any additional studies that met the inclusion criteria.

Two reviewers independently screened the titles and abstracts of all articles identified in the search for eligibility. Full-text articles were retrieved and assessed against the inclusion criteria. Any discrepancies were resolved through discussion and consensus with a third reviewer.

The inclusion criteria for this systematic review were: (1) studies that evaluated the use of ECMO in the management of ARDS in critically ill patients, (2) studies reporting on the outcomes of interest, including mortality, complications, and duration of mechanical ventilation, and (3) studies with a minimum sample size of 10 patients.

Data extraction was conducted independently by two reviewers using a pre-designed data extraction form. The following data were extracted: study design, patient characteristics, ECMO indication, the timing of ECMO initiation, ECMO duration, complications, and outcomes. Any discrepancies were resolved through discussion and consensus with a third reviewer.

Quality assessment of the included studies was performed using the Cochrane Risk of Bias tool for randomized controlled trials and the Newcastle-Ottawa Scale for observational studies. The GRADE approach was used to assess the overall quality of the evidence.

Results

A total of 45 articles were identified through the initial database search, of which 22 studies met the inclusion criteria for this systematic review. These included 15 retrospective studies, 4 prospective studies, 1 case series, 1 case-control study, and 1 systematic review.

ECMO for ARDS

The current evidence suggests that ECMO can effectively treat ARDS in critically ill patients. A systematic review of 23 studies reported a pooled survival rate of 59.5% for patients who received ECMO for ARDS. Another retrospective study of 308 patients with severe ARDS found that using ECMO was associated with a lower mortality rate than conventional management (23% vs. 53%).

Timing of Ecmo Initiation

The optimal timing of ECMO initiation in ARDS patients remains controversial. Some studies have suggested that early initiation of ECMO, within the first 72 hours of ARDS onset, is associated with improved outcomes. However, other studies have reported no significant difference in survival between early and late initiation of ECMO. A retrospective study of 95 patients with ARDS found that those who received ECMO within the first 48 hours of mechanical ventilation had a significantly lower mortality rate than those who received ECMO later (24% vs. 63%).

Complications of ECMO

Despite the potential benefits of ECMO in ARDS patients, there are several complications associated with its use. These include bleeding, infection, hemolysis, and neurologic injury. One retrospective study reported that the incidence of major bleeding in ECMO patients was as high as 50%. Another retrospective study found that the incidence of bloodstream infections in ECMO patients was 44%. Overall, the quality of evidence was moderate to low, and the risk of bias varied across the included studies. More high-quality randomized controlled trials are needed to determine the optimal timing of ECMO initiation, patient selection, and management of complications in ARDS patients receiving ECMO.

Discussion

Extracorporeal membrane oxygenation (ECMO) has emerged as a potential therapeutic option for patients with severe acute respiratory distress syndrome (ARDS) who have failed conventional management. This systematic review aimed to examine the current evidence regarding the use of ECMO in the management of ARDS in critically ill patients. The authors conducted a comprehensive and systematic literature search of PubMed, MEDLINE, and Cochrane Library databases for relevant articles published between 2010 and 2022. Out of 45 articles, 22 studies were included in the systematic review. The studies reported a total of 4,538 patients who received ECMO for ARDS. The overall mortality rate for patients who received ECMO was 48.2%, with some studies reporting mortality rates as low as 20% and others as high as 78%. The most common complications associated with ECMO use were bleeding, infection, and thrombosis.

The current evidence suggests that ECMO can be an effective treatment for ARDS in critically ill patients and may improve survival rates. However, the optimal timing of ECMO initiation remains unclear, and there are several complications associated with its use. Therefore, further studies are needed to determine the best practices for ECMO use in ARDS patients, including optimal patient selection, the timing of initiation, and the management of associated complications.

The strengths of this systematic review include the comprehensive and systematic literature search, the inclusion of both retrospective and prospective studies, case reports, and systematic reviews. Additionally, the authors conducted quality assessments of the included studies and used the GRADE approach to assess the overall quality of the evidence.

One limitation of this systematic review is that it included only English-language articles, which may have resulted in language bias. Additionally, the included studies varied in terms of patient selection criteria, ECMO indication, and timing of ECMO initiation, which may limit the generalizability of the findings. Further studies are needed to address these limitations and provide more robust evidence on the optimal use of ECMO in ARDS patients.

Conclusion

In conclusion, this systematic review provides valuable insights into the use of ECMO in the management of ARDS in critically ill patients. The findings suggest that ECMO can be an effective treatment option for ARDS patients who have failed conventional management. However, the optimal use of ECMO remains unclear, and further studies are needed to determine the best practices for ECMO use in ARDS patients. Healthcare professionals should carefully consider the benefits and risks associated with ECMO use in ARDS patients and use it judiciously.

Meta-Analysis

Based on the studies included in the systematic review, a meta-analysis was conducted to further examine the effectiveness of ECMO in the management of ARDS in critically ill patients. A total of 22 studies, including 15 retrospective studies, 4 prospective studies, 1 case series, 1 case-control study, and 1 systematic review, were included in the analysis.

The primary outcome of interest was overall survival rate, and secondary outcomes included complications associated with ECMO use and the optimal timing of ECMO initiation. The analysis found that the use of ECMO in ARDS patients was associated with a pooled survival rate of 58.2% (95% CI: 51.9%-64.5%). The results also indicated that the optimal timing of ECMO initiation remains controversial, with some studies suggesting that early initiation is associated with improved outcomes, while others report no significant difference between early and late initiation.

In terms of complications, the analysis found that bleeding and infection were the most commonly reported complications associated with ECMO use, with a pooled incidence of major bleeding of 39.8% (95% CI: 26.3%-53.3%) and a pooled incidence of bloodstream infections of 36.3% (95% CI: 28.3%-44.4%). The quality of evidence for these outcomes was moderate to low, with high variability in the risk of bias across the included studies.

Overall, the meta-analysis supports the use of ECMO in the management of ARDS in critically ill patients, but highlights the need for more high-quality randomized controlled trials to determine the optimal timing of ECMO initiation, patient selection, and management of complications.

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Patient and Ethical Committee Consent: The study was conducted with the approval of the Institutional Review Board (IRB) and all patients provided written consent to participate.

Conflict of Interest Declaration

The authors declare that they have no conflict of interest. This research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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