Review Article

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Continuous Renal Replacement Therapy in Critically Ill Patients: Benefits, Challenges, and Perspectives in the Management of Acute Kidney Injury.

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ABSTRACT

Acute kidney injury (AKI) is a common complication in critically ill patients admitted to Intensive Care Units (ICUs), often associated with high morbidity and mortality rates. Continuous Renal Replacement Therapy (CRRT) stands out as an effective alternative for managing these patients, particularly in the presence of hemodynamic instability. This literature review analyzed the available evidence on CRRT use in ICUs, addressing its principles, benefits, challenges, and limitations. CRRT offers advantages such as gradual solute and fluid removal, cardiovascular stability, and potential inflammatory modulation in critical conditions like sepsis and multiple organ dysfunction syndrome. However, challenges such as high costs, the need for anticoagulation, and specific infrastructure were highlighted. Although CRRT is widely recommended for critically ill patients, the literature reveals gaps in protocol standardization and the assessment of long-term outcomes, such as renal recovery and mortality reduction. The study concludes that CRRT should be used judiciously, considering the patient's clinical conditions and available resources. Additionally, the need for further research is emphasized to optimize clinical practice and expand access to therapy. This work contributes to understanding the importance of CRRT in managing AKI in ICUs and developing more effective and accessible strategies.

Keywords: Continuous Renal Replacement Therapy; Intensive Care Unit; Acute Kidney Injury

INTRODUCTION

Acute kidney injury (AKI) is a common condition in critically ill patients admitted to Intensive Care Units (ICUs), affecting up to 50% of these individuals, depending on the severity of the case and the presence of comorbidities. This dysfunction is characterized by a rapid reduction in renal function, resulting in the accumulation of metabolic waste, electrolyte imbalances, and metabolic acidosis, significantly impacting the survival of these patients (KDIGO, 2012). In critical scenarios, renal replacement therapy is often necessary to maintain metabolic balance and prevent systemic complications from renal failure.

Continuous Renal Replacement Therapy (CRRT) emerges as a particularly relevant modality in contexts of hemodynamic instability, a common characteristic in patients with multisystem dysfunction or septic shock. Unlike intermittent dialysis, CRRT provides the gradual and continuous removal of fluids and solutes over 24 hours, promoting greater cardiovascular stability and metabolic control, which is essential in severe cases (Ronco et al., 2015). This modality can be applied in different ways, such as continuous venovenous hemofiltration (CVVH), continuous venovenous hemodialysis (CVVHD), or continuous venovenous hemodiafiltration (CVVHDF), depending on the specific needs of each patient (Kellum & Lameire, 2013).

Although continuous dialysis offers clinical advantages, such as a lower incidence of hypotension and better hemodynamic tolerance, it also presents considerable challenges. These challenges include high costs, the technical complexity of managing the extracorporeal circuit, the need for anticoagulation to prevent filter clotting, and the risk of complications such as metabolic imbalances and infections related to the central venous catheter (Bellomo et al., 2017). Additionally, the literature still debates the clinical outcomes associated with CRRT use, including its influence on mortality

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and long-term renal function recovery.

In this context, the choice between CRRT and other modalities, such as intermittent hemodialysis, must be carefully weighed based on the patient's clinical conditions, available resources, and current guidelines. Despite significant advances in AKI management in ICUs, important knowledge gaps still exist, particularly concerning therapy individualization and the standardization of clinical protocols (Goldstein et al., 2020).

This review aims to explore the fundamentals of Continuous Renal Replacement Therapy, highlighting its indications, benefits, and limitations in the context of intensive care. Furthermore, it seeks to critically evaluate the available scientific evidence and identify opportunities for future advances in managing acute kidney injury in critically ill patients.

METHODS

This study was conducted as a literature review aiming to critically analyze the existing scientific literature on Continuous Renal Replacement Therapy (CRRT) in critically ill patients admitted to Intensive Care Units (ICUs). A systematic approach was adopted, encompassing the steps of searching, selecting, and synthesizing relevant information, as described below.

The search strategy was developed with the help of recognized databases such as PubMed, Scielo, Embase, Cochrane Library, and Google Scholar. In these platforms, keywords and descriptors in Portuguese and English were used, combined with Boolean operators (AND, OR), such as: "Continuous Renal Replacement Therapy" AND "Intensive Care Unit"; "Terapia de substituição renal contínua" OR "diálise contínua"; "Acute Kidney Injury" AND "Critical Care." To ensure the precision and comprehensiveness of the results, controlled terms like those in the MeSH (Medical Subject Headings) vocabulary, applicable in PubMed, were used.

Inclusion criteria stipulated that studies published in the last 10 years (2013-2023), peer-reviewed, and addressing CRRT application in critically ill patients with acute kidney injury would be selected. Additionally, only articles available in Portuguese, English, or Spanish were considered. Conversely, studies focused on chronic dialysis, those not involving intensive care settings, duplicates across databases, and publications without access or clear methodology were excluded.

The screening of articles followed three main steps: an initial review of titles and abstracts to assess relevance; a full-text analysis to confirm suitability to the review's scope; and data extraction, recording the objectives, methodology, key results, and conclusions of each selected article.

The collected data were organized into thematic categories, including CRRT principles and modalities, clinical indications, benefits, comparisons with other dialysis modalities, and associated complications. The analysis was conducted descriptively and critically, integrating evidence to offer a comprehensive and relevant overview of CRRT use in intensive care settings.

It is important to note the limitations of this study. The review is restricted to literature accessible in the selected databases and the considered publication period. Furthermore, potential selection biases may have occurred due to the inclusion of studies only in Portuguese, English, and Spanish.

With this method, we aim to ensure the validity and quality of the presented information, contributing to understanding the most relevant aspects of CRRT in critically ill patients.

RESULTS AND DISCUSSION

The literature analysis revealed that Continuous Renal Replacement Therapy (CRRT) has become widely used in managing critically ill patients with acute kidney injury (AKI), especially those with hemodynamic instability. Recent studies demonstrate that CRRT is preferred over intermittent dialysis in high cardiovascular risk situations because it provides more gradual removal of fluids and solutes, reducing the incidence of intradialytic hypotension (Ronco et al., 2015).

Among the CRRT methods, the most common modalities are continuous venovenous hemofiltration (CVVH), continuous venovenous hemodialysis (CVVHD), and continuous venovenous hemodiafiltration (CVVHDF). Each of these techniques has specific characteristics that allow their adaptation to the patient's clinical conditions, with the choice often guided by the need for fluid removal or metabolic control (Kellum & Lameire, 2013).

Another significant finding concerns CRRT's application in sepsis and multiple organ dysfunction syndrome (MODS) contexts. In this scenario, continuous therapy has been associated with additional benefits, such as the removal of inflammatory mediators and cytokines, although the clinical impact of this mechanism remains a topic of debate in the literature (Bellomo et al., 2017). Moreover, CRRT has shown effectiveness in reducing pulmonary edema and managing complications related to fluid overload, factors directly associated with improved oxygenation and respiratory outcomes in critically ill patients (Goldstein et al., 2020).

Despite its advantages, CRRT presents challenges and limitations that must be considered. The high cost of therapy, associated with the need for specific equipment and trained teams, is often cited as one of the main barriers to its widespread implementation, particularly in developing countries (Ronco et al., 2015). Furthermore, the need for anticoagulation to prevent circuit clotting poses a bleeding risk, especially in patients with coagulopathies or concurrent use of other anticoagulant therapies (Bellomo et al., 2017).

Although the literature supports CRRT use in unstable patients, some studies suggest that the benefits regarding mortality and long-term renal function recovery are similar to those observed in intermittent dialysis, provided it is adequately applied (Kellum & Lameire, 2013). This highlights the importance of careful patient selection, considering individual clinical conditions, available resources, and institutional protocols.

Another point of discussion is the heterogeneity of the analyzed studies, which complicates protocol standardization for CRRT. There is significant variability regarding prescribed dialysis doses, anticoagulation use, and hemodynamic and metabolic parameter monitoring. These differences may impact clinical outcomes, emphasizing the need for more randomized controlled studies to guide evidence-based practices (Goldstein et al., 2020).

Finally, it is noteworthy that CRRT's role goes beyond renal replacement, being considered an adjunct therapy in supporting critically ill patients with multiple organ dysfunction. However, to optimize the benefits of this modality, investing in professional training, technological updates, and developing clear guidelines for its application is essential (Bellomo et al., 2017).

CONCLUSIONS

Continuous Renal Replacement Therapy (CRRT) plays a fundamental role in managing critically ill patients with acute kidney injury (AKI), especially those with hemodynamic instability or multisystem dysfunction. This literature review highlighted CRRT's advantages over intermittent dialysis, including greater cardiovascular stability, continuous and gradual removal of solutes and fluids, and potential benefits in inflammatory modulation in scenarios such as sepsis and multiple organ dysfunction syndrome.

Despite its advantages, implementing CRRT faces significant challenges, such as high costs, the need for specific infrastructure, and proper management of complications like circuit clotting and anticoagulation-associated bleeding risks. These factors, combined with the heterogeneity of available studies, reinforce the importance of an individualized and evidence-based approach to using this therapeutic modality.

Findings suggest that CRRT should be used judiciously, considering each patient's clinical needs, available institutional resources, and established guidelines. Although its use is widely indicated in critically ill patients, the literature still presents gaps regarding protocol standardization, dialysis dose, and its impact on long-term outcomes, such as renal function recovery and mortality reduction.

Therefore, to maximize CRRT's benefits, it is essential to invest in more robust studies exploring its application in different clinical contexts and in professional training to optimize its use. Additionally, efforts should focus on expanding access to this therapy in resource-limited settings, ensuring that technological and clinical advances benefit a broader population.

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