

Symposium

Introduction

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Continuous Renal Replacement Therapies: Raising the Bar for Quality Care

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Continuous renal replacement therapy (CRRT) has become a standard therapy option and has been widely used for critically ill patients requiring renal support since it was introduced 4 decades ago.¹⁻⁴ Patients requiring CRRT are typically at high risk of death related to their severity of illness, and mortality rates in this population have remained steady around 50% since the advent of CRRT.⁵⁻⁸ The advances in CRRT hemofilter supplies and device technologies in the past 2 decades aimed to improve safety and quality in delivery of this therapy. Despite these improvements, the variability in CRRT practice has been implicated as a potential contributing factor in morbidity and mortality outcomes for patients receiving this therapy.^{9,10} Patients who require CRRT are especially vulnerable for poor outcomes because of the severity of their critical illness, which potentially limits their resiliency to standard practice breaches and related complications.⁹ This symposium is intended to increase awareness and knowledge of best-practice strategies for safe and high-quality CRRT care that improve patients' outcomes. The articles in this symposium present a review of best-practice quality recommendations for CRRT, including recommendations from a recent expert consensus conference,¹¹ a model for CRRT training and competency evaluation that expands beyond initial orientation, an overview of considerations for medication management during CRRT, and a series of 3 case vignettes that highlight different applications of CRRT that are based on patient-specific goals of therapy.

History and Nomenclature

Continuous arteriovenous hemofiltration (CAVH) was first described in 1977 after 12 critically ill patients with severe fluid overload and renal dysfunction were treated with an alternative to intermittent hemodialysis (IHD) and peritoneal dialysis.¹² Arteriovenous therapies including CAVH and continuous arteriovenous hemodialysis (CAVHD) require an arterial and a venous access catheter, and the driving pressure through the circuit relies on the patient's mean arterial pressure. In the early 1990s, continuous venovenous hemofiltration (CVVH), continuous venovenous hemodialysis (CVVHD), and continuous venovenous hemodiafiltration (CVVHDF) using a dual-lumen catheter for venous vascular access and a blood pump device were introduced.^{13,14} Advantages of venovenous therapy over arteriovenous therapy include avoidance of risks associated with arterial vascular access catheters and provision of reliable

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blood flow rates through the circuit. The use of the term CRRT became more widespread as the comprehensive term for the aforementioned continuous arteriovenous and venovenous therapies along with slow continuous ultrafiltration (SCUF). The advent of the term *prolonged intermittent renal replacement therapy* (PIRRT) came about to differentiate therapies that were similar to CRRT, but were not continuous and yet were longer in duration than conventional IHD.¹⁵ A more complete review of CRRT nomenclature and therapy differences is beyond the scope of this symposium and can be found in the literature.¹⁵⁻¹⁷

Quality of CRRT Care

As the use of CRRT for renal support in critically ill patients has increased in the past decades, the need for quality standards for CRRT programs has become more apparent to direct care clinicians, clinical educators, nephrology and critical care medicine fellowship directors, and administrators of hospitals and health systems. Along with expectations for intensive care units (ICUs) to provide CRRT as the first-line renal support option for patients with hemodynamic instability, the need for quality standards for CRRT programs is a result of the increase in acute kidney injury (AKI) and CRRT research and challenging experiences including adverse events related to CRRT. The complexity of CRRT care and the related risk for harm is discussed in this symposium as background to the recent recommendations from the Acute Disease Quality Initiative (ADQI) consensus conference on CRRT.

Although standardization is a key tenet of the science of safety and quality care, patient-centered care that is individualized or adjusted from the standard to meet the patient's unique disorder, response to the therapy, or situation is also a key tenet of quality health care. The case vignettes presented in this symposium by Garwood et al are just a few examples of how standard CRRT administration can be adjusted to the patients' unique situations. Patients with AKI due to rhabdomyolysis can benefit from high-volume hemofiltration doses that are well beyond the standard recommended dose of 25 mL/kg per hour. Achieving goals for fluid balance with high net fluid-removal rates can be accomplished with CRRT in patients with decompensated heart failure

who have low cardiac output states and related hypotension and hemodynamic instability. Patients with severe acute respiratory distress syndrome or cardiopulmonary failure requiring extracorporeal life support who have AKI and/or severe fluid overload can also receive CRRT with setup options to meet unique needs.

Training and Competency

The need for CRRT training programs with content beyond the management of the extracorporeal blood circuit and CRRT device has also been identified in tandem with the increase in the use of CRRT in ICUs. The 2 CRRT nurse management models have influenced some of the variability in the curricula for CRRT training programs and in competency expectations. The critical care nurse management model and the acute hemodialysis nurse and critical care nurse shared-management model are both effective models for delivering CRRT and require the same standards of training and competency.¹⁸⁻²⁰ Although the importance of CRRT-qualified nurses is discussed and recommended throughout the CRRT literature, no consensus recommendations are available for the curriculum content, methods of training, or competency assessment for CRRT training programs. The ADQI consensus recommendations acknowledge the importance of CRRT training and the impact of the advanced knowledge and skills on reducing potential complications and optimizing quality indicators, such as achieving therapy targets.²¹ Further work on establishing recommendations for CRRT training and competency programs for nurses and other critical care clinicians is warranted.

A few articles that outline successful programs at individual institutions or health systems have been published.^{18,22-24} Sharing best practices that address unique ICU needs and CRRT volume needs continues to be a source of evidence to optimize CRRT training programs. In this symposium, Przybyl et al present a comprehensive CRRT training program that was designed using adult learning and skill acquisition theories.^{25,26} Strategies to address challenges of training and maintaining competency in different ICUs with varying volumes of CRRT days within a large health system are presented, including use of simulation training.

Medication Management

The increase in CRRT use has also resulted in more published studies and case reports related to CRRT and drug pharmacokinetics and management of toxic effects of drugs. Despite this, safe and therapeutic drug delivery remains a challenge for clinicians managing patients undergoing CRRT. The variability in both patient-specific and CRRT-specific factors along with their relationship to drug-specific factors contributes to this challenge. Pharmacokinetics of drug clearance during CRRT are affected by the varying degrees of residual renal function and the high likelihood of extravascular fluid overload and muscle wasting seen in critically ill patients. The mode of CRRT, the type of hemofilter membrane, and the dose of therapy also influence drug clearance.

One aim of the medication management article by Thompson et al in this symposium is to outline the drug-, patient-, and CRRT-specific factors that clinicians should incorporate into drug dosing and monitoring during CRRT. Achieving goals of CRRT dosing are reliant upon the therapy running continuously with minimal interruptions. Clotting within the hemofilter, circuit, and vascular access catheter is a common cause of circuit failure during CRRT. The activation of the coagulation system may be related to the patient's comorbid condition, current critical illness, the nonlaminar blood flow in the catheter and circuit, and/or the blood interface with the nonbiologic hemofilter and circuit tubing. The second aim of this article is to present an overview of the medication management options for use of anticoagulation during CRRT and to outline related best-practice strategies to optimize effective and safe CRRT anticoagulation.

Summary

The goal of this CRRT symposium is to provide information that increases awareness and knowledge that leads to (1) critical thinking during assessment, planning, implementation and evaluation of critically ill patients receiving CRRT; (2) design and implementation of CRRT training and competency programs; and (3) planning and development of CRRT standards of care, procedures, and/or protocols that include a quality monitoring component. As with all other critical care interventions, providing safe and high-quality

CRRT care is reliant on strong leadership, effective interprofessional team collaboration, and system-based programs to ensure optimal outcomes for patients.

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