The renal replacement therapy in critically ill patients: Practical approaches in specific situations based on case reports

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Abstract:

Acute kidney injury (AKI) is a common diagnosis in daily clinical practice, occurring in virtually all fields of medicine. Critically ill patients are especially prone to the development of AKI due to frequent hemodynamic instability, multiple risk factors and, diagnostic and/or treatment complications. For these and other reasons, critical care nephrology plays an irreplaceable role in treating critically ill patients in ICUs. The aim is to present overview using relevant scientific research results, along with the authors own practical clinical experience with renal replacement therapy (RRT) in specific clinical situations (case reports) from the University Hospital of Ostrava in the Czech Republic. Treatment of AKI associated with rhabdomyolysis in patient with abdominal aortic aneurysm and ischemia-reperfusion syndrome. Efficacy of plasmapheresis for hypertriglyceridemia induced acute pancreatitis in pregnancy associated with abdominal compartment syndrome and the practical use of hemoperfusion with Cytosorb in patients suffered from sepsis and multiple organ dysfunction syndromes. Many issues can be expected in these specific situations including complications and benefits of treatment. Knowledge of the indications, existing data on the actual results of and not least, the complications of extracorporeal blood purification techniques, provide a perspective for the clinician.

Introduction

Acute kidney injury (AKI) has a significant association with high mortality in critically ill patients. Acute renal replacement therapy (RRT) provides supportive management for patients with severe AKI and multiorgan failure (MOF). Continuous renal replacement therapy (CRRT), in particular, is utilised for a haemodynamically unstable patient with AKI in an intensive care unit (ICU) setting. This is the standard practice in most ICUs' in the United Kingdom (UK) and the Republic of Ireland. However, limited consensus exists regarding RRT timing, optimum dosing, modality, and therapeutic efficacy beyond AKI management. In light of emerging data, we look to provide an evidence-based review to address these issues.

The available modalities of renal replacement therapy include:

- Peritoneal dialysis
- Intermittent hemodialysis
- Continuous renal replacement therapies

Peritoneal dialysis:

Peritoneal dialysis uses the peritoneum as a natural semi-permeable membrane for diffusive removal of solutes. It is a very effective treatment modality in patients with chronic renal failure, and patient outcomes are at least equivalent to those treated with hemodialysis. Peritoneal dialysis is also valuable in pediatric critical care where vascular access is challenging and peritoneal surface area is relatively larger than in adults.

In adult patients, acute peritoneal dialysis is not widely used. The use of peritoneal dialysis is limited by both logistical and practical considerations. Acute peritoneal dialysis requires surgical insertion of a peritoneal dialysis catheter, requiring the additional involvement of a surgical team. Acute PD is frequently complicated by catheter leakage and malfunction. In addition, the use of PD is limited by low solute clearance in hypercatabolic patients, potential pulmonary restriction due to expansion of the peritoneal cavity, and its contraindication in postoperative patients who require abdominal surgery or surgical drains. A study comparing PD with CRRT in critically ill septic patients with ARF showed more rapid correction of acidosis, solute clearance, and significantly improved survival with CRRT.

Intermittent hemodialysis:

Hemodialysis is a process of solute clearance based on diffusion across the membrane driven by a concentration gradient between the blood and dialysate. The total amount of solute transported per unit of time (clearance), depends on the molecular weight of the molecule, membrane characteristics (dialysance), dialysate flow, and blood flow. In general, intermittent dialysis is prescribed for 3–6 h per treatment. Chronic hemodialysis patients are treated three times per week, the adequate dose for IHD in patients with ARF has not yet been determined.

Slow efficiency daily dialysis or EDD is a variant of IHD where the duration of dialysis is extended to between 8 and 12 h, the blood flow is lowered, fluid removal is more gradual, and solute clearance slower. SLEDD is associated with less hemodynamic instability than IHD and provides excellent solute control. This modality may have several advantages over continuous renal replacement therapies with respect to cost and improved patient mobility, however the two therapies have never been compared directly in a clinical trial.

Continuous renal replacement therapy has become increasingly popular for the management of ARF in the critically ill, and is now used to the exclusion of IHD in Australia.

Continuous renal replacement therapies :

CRRT is any renal replacement therapy that is intended to be applied for 24 h per day in an ICU. The term CRRT describes a variety of blood purification techniques, which may differ significantly according to the mechanism of solute transport, the type of membrane, the presence or absence of dialysate solution, and the

type of vascular access. CRRT provides slower solute clearance per unit time as compared with intermittent therapies but over 24 h may even exceed clearances with IHD.

Solute removal with CRRT is achieved either by convection, diffusion, or a combination of both these methods. Hemodialysis most efficiently removes small molecular weight substances such as urea, creatinine, and potassium. Middle and larger molecular weight substances are more efficiently removed using hemofiltration as compared with dialysis. During hemofiltration, hydrostatic pressure causes the filtration of plasma across a semi-permeable membrane. Solutes are dragged across the membrane along with the plasma resulting in convective transport of solutes in the same direction as water. This process requires the use of replacement fluid to prevent iatrogenic acidosis and electrolyte depletion as well as excessive fluid removal. The solutes in the removed filtrate are in the same concentration as those in the plasma, and solute concentration in the remaining plasma is diluted with substitution fluid. Combining diffusive and convective clearance with hemodiafiltration allows improved clearance of both small and large molecular weight substances. Using this method, blood urea nitrogen (BUN) clearances in the range of 23–30 mL/min can be achieved, even in hypotensive patients.

The choice of modality is dependent on several factors including availability, cost, physician expertise, hemo-dynamic stability, and the primary purpose of the procedure (fluid removal vs solute clearance). There is currently only limited information comparing diffusive with convective blood purification techniques; results with CRRT techniques should be compared with those obtainable with IHD, which remains the gold standard therapy.

The most commonly applied modalities are continuous venovenous hemofiltration, continuous venovenous hemodialysis (CVVHD), and continuous venovenous hemodiafiltration. Arteriovenous modes of CRRT have been used in the past, whereby dialysis access was obtained through the femoral artery and the femoral vein. This type of CRRT used the patient's own cardiac output to drive blood through the dialysis circuit. AV forms of CRRT have fallen out of favor in recent years due to the high access complication rate and the development of external circuit pumps. See Table 1 for a comparison of intermittent vs continuous dialysis therapies.

Conclusion:

The role of RRT in the ICU is primarily to support renal dysfunction with MOF. The strategies to employ it are dynamic and evolving. The optimal time to commence RRT remains a topic of literature debate, surgical patients may benefit from early initiation of therapy, whilst septic patients with MOF may benefit from a delayed strategy. CRRT is considered the first line when managing critically ill patients with haemodynamic instability, although no definitive evidence is available to suggest mortality benefits or renal function preservation when compared to IHD. RRT is a potential therapeutic option when managing resistant congestive heart failure; however, other therapies like haemoperfusion in sepsis have proven ineffective. RCA has comparatively lower bleeding risk compared to heparin-based therapy and remains the choice of anticoagulant in CRRT.