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Review Article

Slow low efficiency dialysis in critically sick patients

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ABSTRACT

The management of acute kidney injury (AKI) in critically sick patients in the intensive care unit entails the use of renal replacement therapy. There has been considerable experience in continuous renal replacement therapy (CRRT) in this setting. Recently there has been increased interest in slow low efficiency dialysis (SLED) to treat these patients. In this review, the technical considerations, clinical and practical advantages of SLED are discussed.

1. Introduction

Acute kidney injury (AKI) is a common complication in critically sick patients and is associated with a mortality rate above 50%.[1] As many as 70% of these patients require renal replacement therapy (RRT), making it an important component of the management of AKI in the intensive care units (ICUs). The ideal RRT controls volume; corrects acid–base abnormalities; improves uremia through toxin clearance; promotes renal recovery; and improves survival without causing complications, such as bleeding from anticoagulation and hypotension.[2] RRT for critically sick patients in ICU who have developed acute renal failure (ARF) has traditionally been provided as intermittent hemodialysis (iHD) or continuous renal replacement therapy (CRRT). Recently, prolonged hemodialysis using conventional equipment has been used as an alternative therapy.

2. Synonyms

The most frequently used terms in the literature include "sustained low efficiency (daily) dialysis" (SLEDD), "sustained low efficiency (daily) diafiltration" (SLEDD-f), "extended daily dialysis" (EDD), "slow continuous dialysis" (SCD), "go slow dialysis", and "accelerated venovenous hemofiltration" (AVVH). Recently there has been a proposal to collectively refer to these regimens by the umbrella term "prolonged

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(daily) intermittent renal replacement therapy" (PIRRT).[3] For the sake of simplicity, we shall continue to refer to the hybrid dialysis therapy in critically sick patients as *Slow Low Efficiency Dialysis* (SLED) in this review.

3. Evolution

Continuous hemodialysis was originally described as an arteriovenous technique, a setting in which extracorporeal circuit perfusion is driven by patient arterial pressure.[4] Continuous venovenous hemodialysis (CVVHD) is a logical evolution of this technique, performed with a blood pump and single venous access resulting in higher and more reliable blood flows (and thus solute clearances), and lower vascular complication rates.[5]

CVVHD without filtration was initially performed in the 1980s; investigators found that it was safe and effective (within limits).[6] Apparatuses utilized at that time were developed via the adaptation of existing hemofiltration machines and blood circuitry; any of several commercial dialysate preparations were also used, usually at dialysate flow rates (QD) between 15 and 30 mL/min. The modern practice of CVVHD with or without filtration most commonly utilizes one of many specialized automatic pump systems. However, several negative features emerge when establishing and maintaining such programs.[3] These are summarized in Table 1 below.

For reasons of cost, simplicity, and convenience, initiatives to adapt batch and single pass iHD machinery for CRRT have been ongoing since the late 1980s.[6–10] In recent years it has become possible to implement durable renal replacement programs for critically ill patients using techniques that combine the therapeutic advantages of CRRT with the logistic and cost advantages of iHD.[11]

The programs use adapted iHD equipment including machinery, hemodialyzers, extracorporeal blood circuitry, and on-line fluid production for dialysate and filtrate replacement. Treatments are deliberately intermittent rather than attempting to be continuous, with longer session durations than conventional iHD. Solute and fluid removal are slower than conventional iHD, but faster than conventional CRRT. This allows for scheduled "down time" without compromise in dialysis dose.[3]

Table 1 – Disadvantages of CRRT.

1.	Initial costs of specialized CRRT machinery.
2.	Subsequent running costs of specialized CRRT lines and filters.
3.	Increased costs from reconstituted or commercial fluid for dialysate or filtrate replacement.
4.	Procedural complexities resulting in increased workload for already busy intensive care unit nurses.
5.	Frequent unexpected interruptions to CRRT because of out-of-unit diagnostic and therapeutic procedures, leading to reduction in dialysis dose from "down time".
6.	Expense and inconvenience from unexpected extracorporeal circuitry replacement.

4. Technical considerations

The following are the principle technical considerations that must be addressed when administering SLED in critically sick patients.

4.1. *Hemodialysis machines*

The machine used to provide SLED should ideally have flexible options for dialysate flow (QD) allowing for low flows should the clinical situation mandate low solute clearance and ultrafiltration rate (UFR). These machines should also allow multiple options for hybrid treatment duration, allowing prolonged or even continuous treatments. The operating nurse or technician should be able to easily use the interface preferably with a dedicated SLED screen. With aim to optimize the usage of machines in the dialysis room the machine should be capable of changing between iHD and SLED, allowing either modality to be conveniently chosen at treatment commencement without any resultant delay.

The Fresenius 4008 series machines have been versatile in performing SLED in critically ill patients. These machines have a built-in option for SLED which can be selected from the startup screen without any delay or further adjustment. The Gambro 200S Ultra has also been used for hybrid treatments, although the lower limit of QD on this machine is 300 mL/min. The Fresenius machines are therefore the preferred single pass machines for SLED. Fresenius Genius machine and the NxStage System One hemofiltration machine are the two machines with batch systems that have been used to provide SLED.

4.2. *Dialysate*

Dialysate for the commonly used single pass machines is generated on-line with a bicarbonate proportioning system using reverse osmosis treated tap water. A canister of dialysate concentrate lasts a single treatment without replacement (a maximum of approximately 16–17 h at 100 mL/min, and 5–6 h at 300 mL/min).

For on-line dialysate, there is general concern about the possibility of backfiltration of bacterial contaminant (specifically endotoxin) from the dialysate compartment into the patient. If this were to occur in critically ill patients, it may result in exacerbation of the patient's inflammatory milieu, and perpetuation of microcirculatory insult and cytokine mediated injury. At present, there are insufficient data to justify a strong recommendation as to whether dialysate for diffusive therapies should be of purity greater than that accepted for routine maintenance hemodialysis. On theoretical grounds, many opinion leaders do opt for dialysate cold-sterilization using ultrafilters in the dialysate pathway. However, to date, this remains opinion based and further studies are warranted. Dialysate composition is varied according to clinical need and is often prescribed as Potassium 3 mEq/L, Bicarbonate 28–32 mEq/L and Calcium 1.5–2.5 mEq/L. If the therapy is prolonged beyond 8 h it may be necessary to have higher potassium and lower bicarbonate concentrations.