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ISCCM Manual of RRT & ECMO in ICU

A Reference Book for Practicing Intensivists

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2nd Edition

JAYPEE

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Sustained Low-efficiency Extended Daily Dialysis in ICU

Mahesh Kota, Rajasekara Chakravarthi

INTRODUCTION

Acute kidney injury (AKI) occurs in about 20–50% of patients admitted in intensive care unit (ICU) and close to 20% of them need renal replacement therapy.[1]

Acute kidney injury in ICU is different from end-stage renal disease (ESRD) in the sense that there is a sudden drop in renal capacity against an increased demand (volume/acidosis/dyselectrolytemia) which changes the internal milieu making it non physiological.[2]

The same changes when they happen gradually in chronic kidney disease (CKD) have adaptive compensation in place which allows enough time to lapse before symptoms or signs occur. The rate of nitrogenous waste products generated in the setting of AKI is higher depending on the metabolism/catabolism and there is usually an associated other organ involvement, e.g., cardiovascular instability.

To mitigate these changes when the glomerular filtration rate (GFR) drop is significant or the associated changes are severe, we need to consider external support to improve the outcomes.

Once the diagnosis of AKI stage III is considered, in the absence of effective pharmacological therapies, the care of the patient is limited to supportive management, source control in septic patients, and use of renal replacement therapy (RRT) for metabolic, volume and acid control.

Unfortunately, there is no robust criteria to initiate RRT in AKI and it is purely a subjective decision of treating team (nephrologist and or intensivist).

In recent years the demand versus capacity paradigm to initiate RRT has gained acceptance to determine the timing of initiation of RRT.[3] Thus, the current practice is to start RRT based on clinical context, i.e., severity of illness, number of failed nonrenal organs, fluid overload, and acidosis.

In patients with severe AKI, RRT initiation at an early stage before developing complications such as fluid overload and acidosis may be beneficial to prevent further worsening of overall clinical status.

How should patient with AKI requiring RRT to be managed?

Once a decision is made to initiate RRT, treating team has to choose a modality appropriate for the clinical requirement.

Renal replacement therapies are broadly classified into continuous and intermittent therapies **(Table 1)**.

TABLE 1: Classification of renal replacement therapies.

Variable	*PD*	*SLED*	*CVVH*	*CVVHD*	*CVVHDF*
Access	Peritoneal membrane	IJV/FV	IJV/FV	IJV/FV	IJV/FV
Blood flow	100 mL/min	100 mL/min	100 mL/min	100 mL/min	100 mL/min
Dialysate flow	—	300 mL/min	NA	1,000 mL/h*	1,000 mL/h*
Replacement fluid	—	—	1,000 mL/hr*	NA	1,000 mL/h*
Ultrafiltration	A	B	B	B	B
Anticoagulation	No need	C	C	C	C
Clearance mechanism	Diffusion/ convection	Diffusion	Convection	Diffusion	Diffusion/ convection

(CVVH: continuous venovenous hemofiltration; CVVHD: continuous venovenous hemodialysis; CVVHDF: continuous venovenous hemodiafiltration; FV: femoral vein; IJV: internal jugular vein; PD: peritoneal dialysis; SLED: sustained low-efficiency extended dialysis)
*Will be changed according to the clinical status of patient.
A. Ultrafiltration changes according to transport nature of peritoneal membrane, low in high transporter, average in high average and low average transporter, good ultrafiltration in low transporter.
B. Will be decided upon patient volume status and hemodynamics.
C. Unfractionated heparin/low molecular weight heparin/regional citrate anticoagulation.

INTERMITTENT HEMODIALYSIS

Intermittent hemodialysis (IHD) is traditionally used as maintenance hemodialysis for chronic kidney disease patients. Decision regarding dialysis duration and frequency are purely based on patient metabolic control, volume status, and hemodynamic stability.

Main disadvantages to use IHD in critically ill patient are risk of hypotension and rapid metabolic changes that occur during IHD.[4]

PERITONEAL DIALYSIS

Peritoneal membrane is used as a semipermeable membrane for clearance of solutes and volume.

Advantages of peritoneal dialysis (PD) include technical simplicity, hemodynamic stability, and lack of need for anticoagulation and vascular access. Disadvantages of using PD include that it cannot be done in those with recent abdominal surgery, coagulopathy, hypercatabolic states, etc.[5] It is of particular benefit in those with heart failure.[6]

CONTINUOUS RENAL REPLACEMENT THERAPY

Continuous renal replacement therapy (CRRT) closely mimics normal kidney function as the process is continuous, characterized by slow removal of both fluid and solute, allowing proper vascular refill, slow removal of uremic toxins and electrolytes, and maintaining hemodynamic stability.[7]

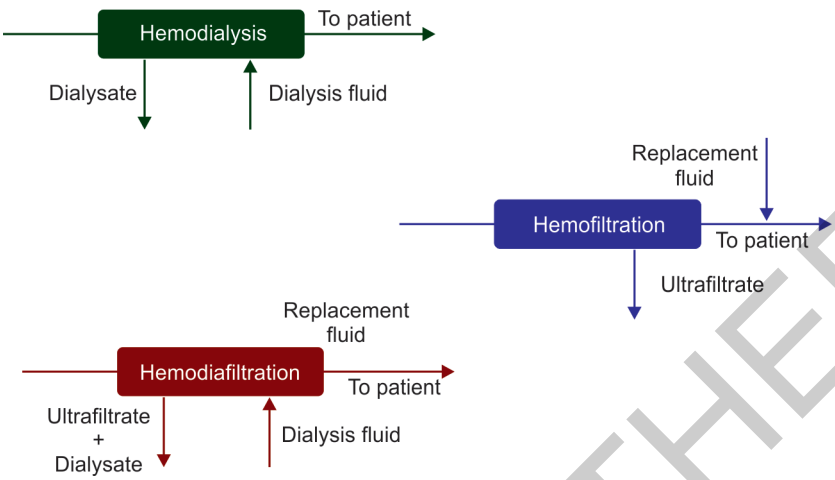

Fig. 1: Replacement fluid in different CRRT modalities.
Source: Comprehensive text book of nephrology, Feehaly 6th edition.

In view of this, CRRT allows any amount of fluid to be given which can be removed hourly and thus helps in improving nutritional status and solute control which can be of immense help in critically ill patients **(Fig. 1)**.[8]

This is the preferred modality in variety of patients with shock. CRRT is of definite benefit in patients with raised intracranial pressure in view of the change in serum osmolality being gradual.[9]

Continuous renal replacement therapy also has a role in variety of nonrenal indications such as sepsis, heart failure, and poisonings.

SUSTAINED LOW-EFFICIENCY EXTENDED DAILY DIALYSIS

First introduced in the 1990s, initially named as EDD or extended daily dialysis. These modalities were thought to replace continuous modalities in total as they do combine the good of both CRRT and IHD techniques.

They are slow dialytic modalities which have the high solute clearance of IHD and also better hemodynamic tolerability of CRRT in view of very slow and gradual solute and fluid removal.[10] Typically they have slow blood pump speed (100–200 mL/min) along with low dialysate flows (200–300 mL/min).

Since introduction they have become quite popular replacing the need for continuous modalities in several settings with good outcomes.

The principle applied in sustained low-efficiency extended dialysis (SLED) is predominantly diffusion but in later years several units across the world have combined diffusion with convection calling them SLED-F.

This modification is popular today and is used in both acute settings and chronic settings as hemodiafiltration (HDF). The filter used here is hi-flux, more porous allowing large volume movements across the membrane. This also means there is solute movement in both direction and thus need ultrapure water for dialysis.[11]

DOSE AND PRESCRIPTION OF RRT FOR SLEDD OR HDF

Protocol of Renown Clinical Services (RCS)

For these modalities the dose depends on whether they are used for acute or chronic settings.

- Typically the duration is for 6–12 hours
- *Frequency:* Daily or per the metabolic needs
- *Dialyzer:* FX 40, FX 60, FX 80, and FX 100
- *Blood flow rate:* 150–300 mL/min
- *Dialysate flow:* 300–400 mL/min

Substitution fluid:

- *Postfilter:* 85–90 mL/kg/h
- *Prefilter:* 2 × postfilter substitution fluid flow rate
- *Pre- and postfilter:* 1.3 × postfilter substitution fluid flow rate
- *Ultrafiltration:* 300–1,200 mL/h or as needed
- *Anticoagulation:* Heparin 2,000 to 10,000 units per session
- *Reuse of dialyzer:* Not recommended
- *Disinfection:* Citrosterile
- *Substitution fluid generation:* Online cold sterilization.

CONCLUSION

Not all patients, who do not tolerate IHD, need CRRT; many can be managed with sustained low-efficiency extended daily dialysis (SLEDD) or SLEDD-F.

Sustained low-efficiency extended daily dialysis is available in most ICUs, easy to use, cost-effective, less labor intensive, and can be initiated by the same nursing staff (ICU or dialysis unit).[12]

In life-threatening hypercatabolic patients, rapid removal of toxins and rapid correction of acidosis and dyselectrolytemia are possible.[13]

It can prevent the development of brain edema in severely uremic patients, avoiding dialysis disequilibrium.[14]

In patients with trauma or neurosurgical intervention and severe hepatic encephalopathy, SLEDD by virtue of gradual change in serum osmolality prevents rise in intracranial pressures though not as friendly as CRRT.[15]

Compared to IHD, SLEDD and SLED-F allow the use of hi-flux filters for ultrafiltration in heart failure patients thus facilitating removal of myocardial depressant factors [interleukin-1 (IL-1), IL-6, and tumor necrosis factor-alpha (TNF-α)].[16]

As the therapy is not for 24 hours, the use of anticoagulant can be avoided in patient with coagulopathy requiring RRT.

The high flows in CRRT are known to reduce the blood levels of lifesaving antibiotics needed additional dosage; this can be avoided in SLEDD.

Sustained low-efficiency extended daily dialysis can be offered as a transition for those patients who were on CRRT and can move to IHD or OPD dialysis on discharge.[17]

Take Home Message

- Dialytic support in the ICU setting is very different from the dialysis offered in the chronic outpatient setting.
- Several factors have to be taken into consideration before deciding on initiation of dialysis.
- Timing, modality and details of prescription depend on catabolic state, presence or absence of sepsis, presence of fluid overload state, level of azotemia and dyselectrolytemia.
- In the setting of MOF and hemodynamic instability most ICUs across the world prefer continuous therapies.
- However in resource limited countries all stakeholders should consider SLEDD as an option in view of the cost and other advantages discussed.
- There is no superiority of one modality over the other. A good unit should have the wherewithal to offer a therapy to the patient according to the need.

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Salient Features

- This book is a comprehensive practical guide for management of extracorporeal therapies in ICU and consists of two sections: *Renal Replacement Therapies and Extracorporeal Membrane Oxygenation*.
- The different subsections describe machines, various components including circuit and operation of machine along with integration of machines with the patient along with initiation, monitoring and management of these critically ill patients
- The book covers common complications encountered during extracorporeal therapies, their identifications and management
- The content of book has been simplified and have been presented in the form of tables, diagram, algorithm, and checklist for easy and better understanding
- The use of modalities on the case-based situation has been described such as extracorporeal carbon dioxide removal (ECCO2R), extracorporeal membrane oxygenation (ECMO) uses in toxicology, ECMO-CPR and uses of extracorporeal therapies in sepsis
- Organization of team, administrative issues, communication, and cost-effective management of extracorporeal therapies have been covered for better understanding of beginners
- Written by eminent experts in the field of ECMO, Nephrology, Critical Care, Pediatric Intensive Care and Cardiac Anesthesia, making a nice blend of academics, clinical expertise and experience.
- An ideal bedside reference guide for all working in the intensive care unit, including Critical Care Physician, Trainee Intensivist, Critical Care Nephrologist, Perfusionists, Critical Care Nurses and Dialysis Technician who are involved in extracorporeal management.
- The MCQ section will help to quickly self-evaluation of the candidate appearing for examination.

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Printed in India

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Daryaganj, New Delhi - 110 002, INDIA
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