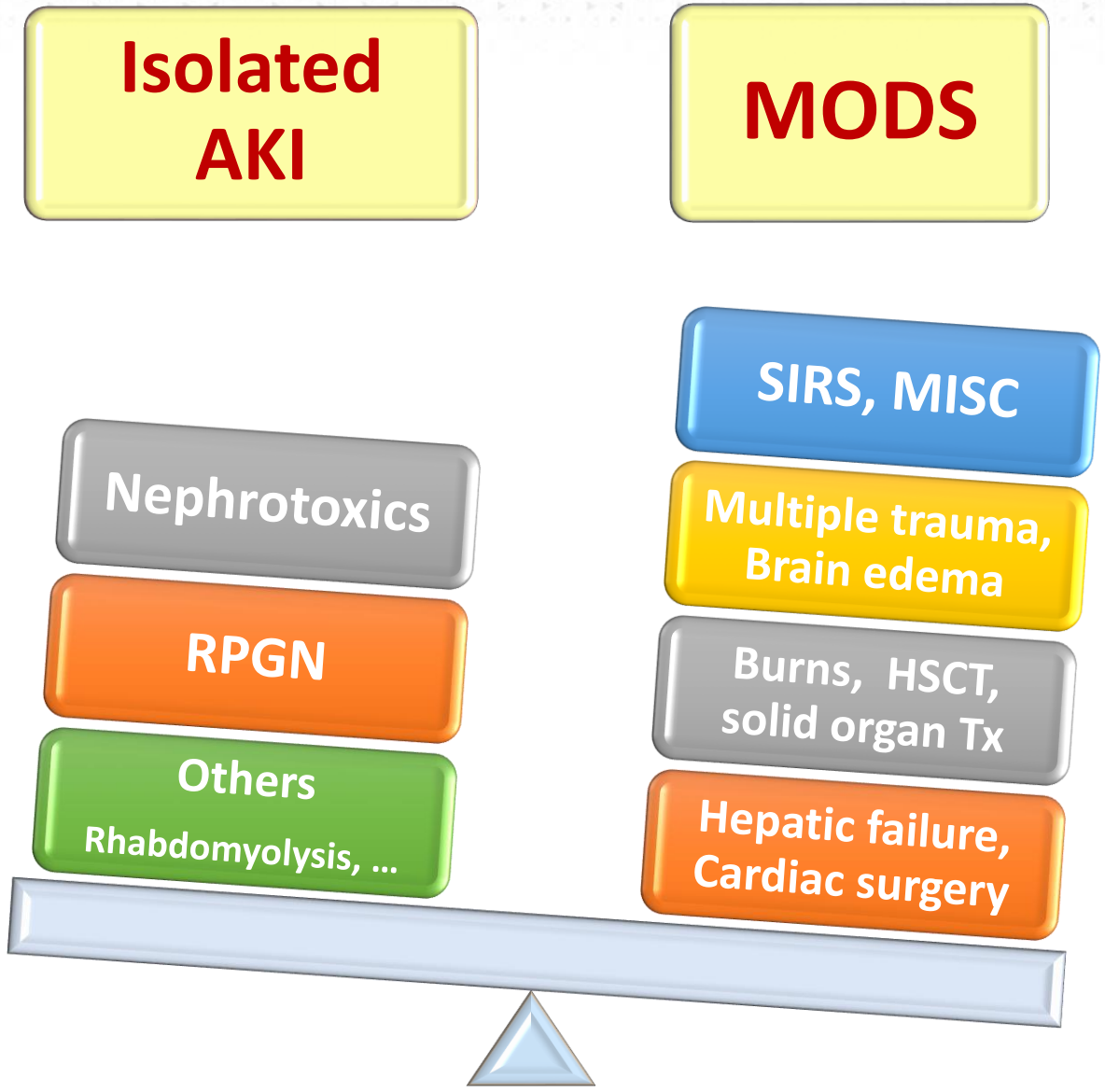

بسم الله الرحمن الرحیم

Pediatric CKRT (CRRT)

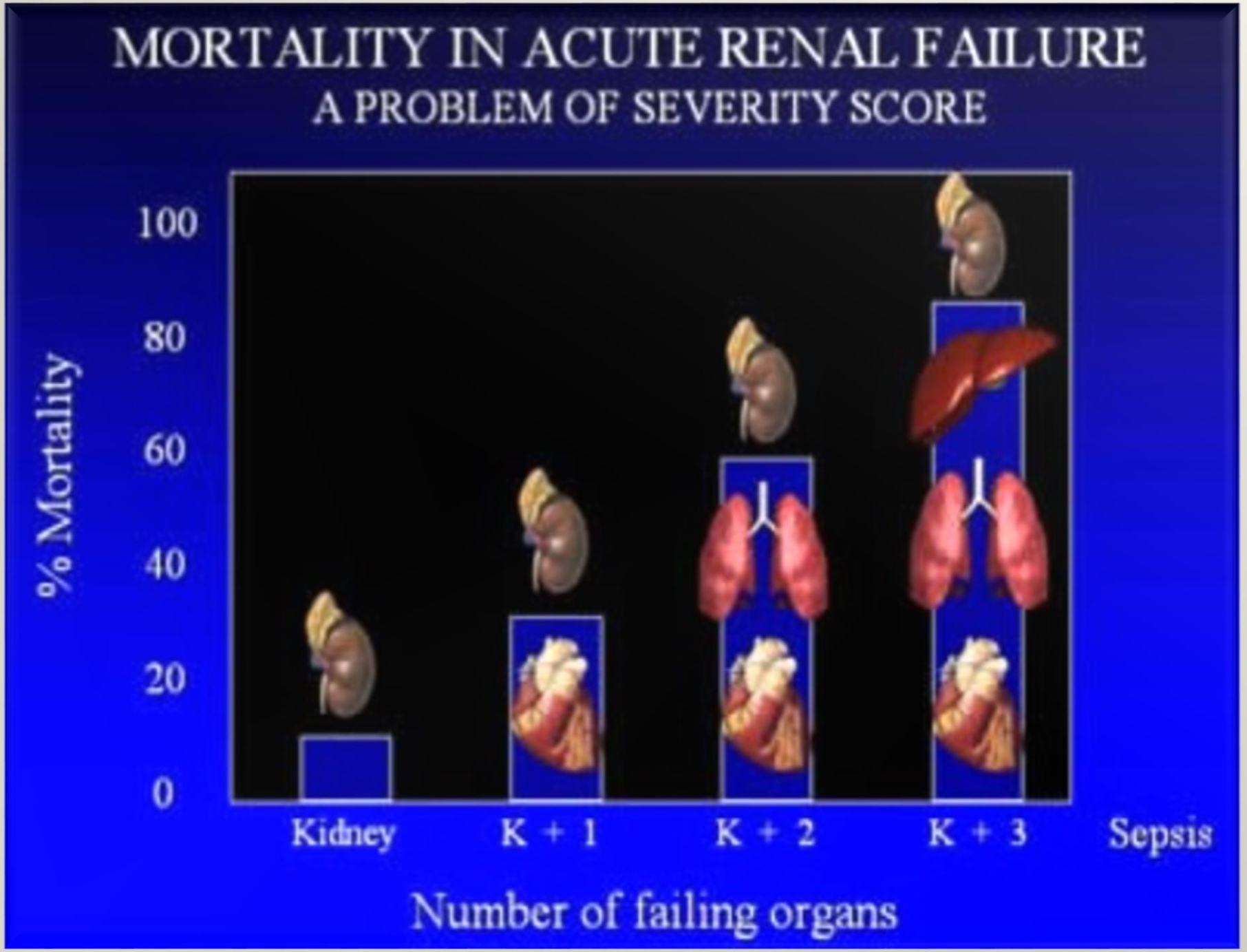
Masoumeh Mohkam, MD
Professor of Pediatric Nephrology,
Shahid Beheshti University of Medical Sciences
Tehran, Iran

Oct. 2024


Isolated AKI
MODS
Nephrotoxics
RPGN
Others
Rhabdomyolysis, …
SIRS, MISC
Multiple trauma, Brain edema
Burns, HSCT, solid organ Tx
Hepatic failure, Cardiac surgery

MORTALITY IN ACUTE RENAL FAILURE

A PROBLEM OF SEVERITY SCORE



Indications for Pediatric CRRT

Renal indications:
Non-renal indications:

Renal indications:

AKI complicated with:

- **Hypotension / hypo perfusion**
- **Heart failure**
- **Volume overload (> 10% /Persistent edema)**
- **Severe electrolyte imbalance refractory to medical treatment**

Indications for Pediatric CRRT (continue)

Non-renal indications:

- **SIRS (Systemic inflammatory response)**
- **Sepsis, MIS-C**
- **MODS, MOF (Multi-organ failure)**
- **ARDS (Adult respiratory distress syndrome)**
- **Crush syndrome**
- **Tumor lysis syndrome**
- **Inborn errors of metabolism (**hyperammonemia refractory to medical treatment)
- **Intoxications**
- **Hypercatabolism/ Severe burns**
- **Acute or chronic liver failure (**removal of toxic metabolites)
- **Brain swelling**
- **Need to make room for more fluids** (drug therapy and/or nutrition)

% FO ? (fluid overload)

Fluid stewardship and fluid restriction in critically ill children after the initial resuscitation phase are very important to prevent severe FO

% FO = Fluid in – fluid out

/ intensive care admission body weight in kg × 100

6% increase in the odds of **mortality** for every 1% increase in FO

Goldstein SL, Pediatrics 2001;107(6):1309–1312
Alobaidi R, JAMA Pediatr 2018;172(3):257–268

Improves oxygenation/ Inflammation

CRRT, which is indicated for acute fluid overload (FO) as well as acute renal failure, improves oxygenation in patients with respiratory failure.

Mechanisms:

- Fluid removal
- Clearance of toxic substances
- Through continuous removal of inflammatory mediators

Elbahlawan L, Pediatr Blood Cancer. 2010;55:540-545.
Hoste EA, Nephrol Dial Transplant. 2002;17:2153-2158.
Cui HX, Eur Rev Med Pharmacol Sci. 2014;18:2523-2526

Estimated total blood volume by age (70 X body weight)

- Currently, CRRT circuits range in extracorporeal volumes from **60 mL to > 250 mL**.
- This suggests that, if the extracorporeal blood volume is > 10% of the intra-vascular blood volume of the child, then blood or Albumin priming may be required

- Cardio-Renal Pediatric Dialysis Emergency Machine **(CARPEDIEM)**
- Newcastle infant dialysis and ultrafiltration system **(Nidus)**
- **CARPEDIEM** has a **27 mL** extracorporeal circuit
- **NIDUS** has a **14 mL** circuit.

Size of the patient

- This is a major consideration for dialysis modality selection as HD and CKRT may not be feasible in infants and small children **<15 kg** in weight.
- In addition, the extracorporeal volume of these circuits typically exceeds 10 percent of the blood volume of small patients.
- For these children, packed red blood cells are required to prime the extracorporeal circuit to prevent hemodynamic instability leading to exposure to donated blood

As a result, PD remains the most common modality used for infants and small children who require KRT

CRRT orders

1. Vascular access
2. Modality
3. Fluid composition
4. Priming solution
5. BFR (Blood flow rate)
6. DFR (Dialysate rate)
7. UFR (Ultrafiltration rate)
8. Heparin/ Citrate
9. FRF (Filter replacement fluid)
10. Filtration fraction

Vascular access

6.5F–12F central venous catheters (GamCath; Gambro, Colombes, France) in the right internal jugular or femoral vein, according to patient body weight

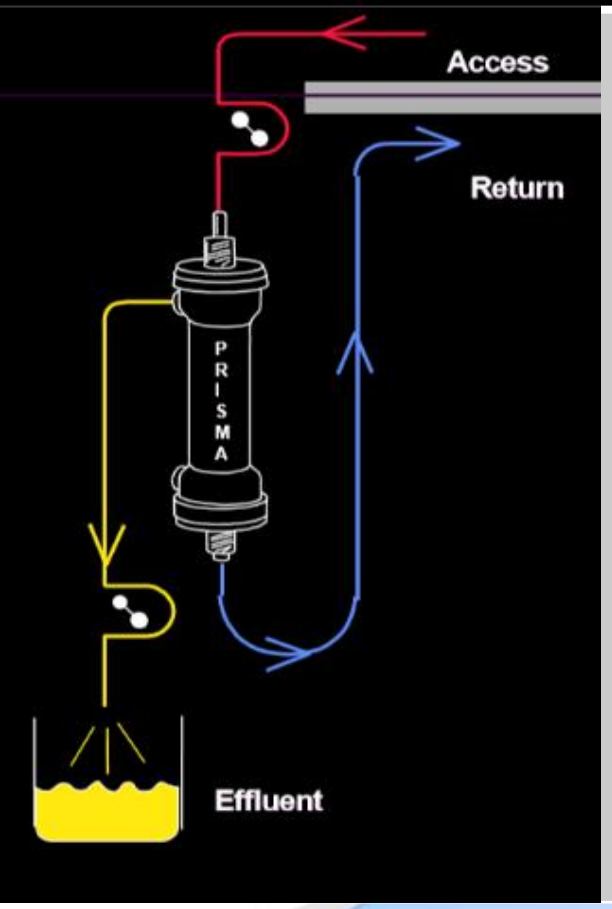
Patient size	Catheter size	Site of insertion
Neonates	Dual lumen **7 Fr**	Internal Jugular
< 10 kg	Dual lumen **7 Fr**	Internal Jugular
10-20 kg	Dual lumen **8 Fr**	Internal Jugular
20-30 kg	Dual lumen **9 Fr**	Internal Jugular
> 30 kg	Dual lumen **10 Fr** Triple lumen **12.5 Fr**	Internal Jugular

CRRT Modality

Volume overload

SCUF

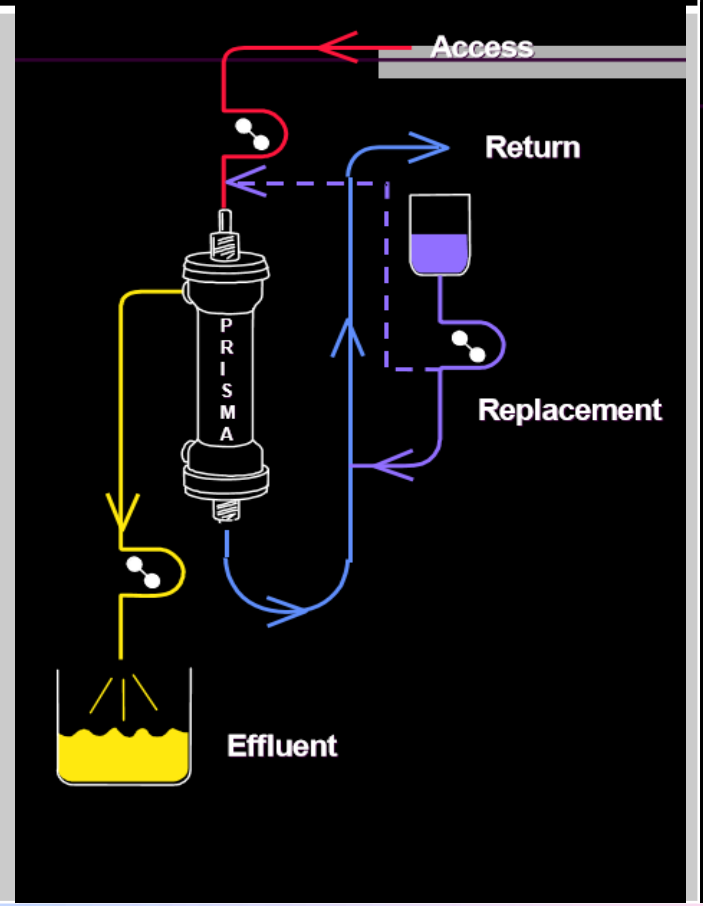
Slow continuous
UltraFiltration



Hypoperfusion

CVVH

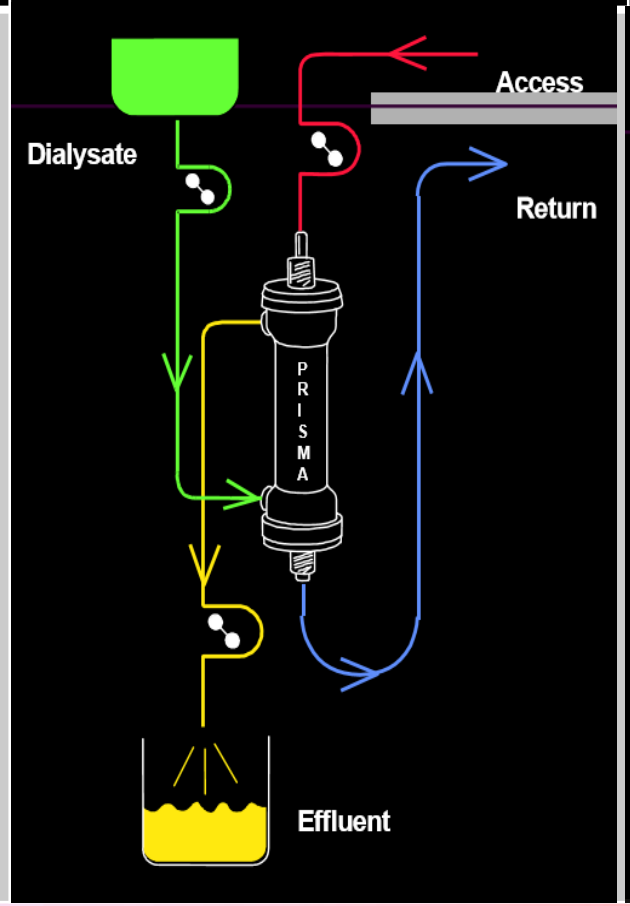
Continuous
veno-Venous
HemoFiltration



Volume overload
Continues HD

CVVHD

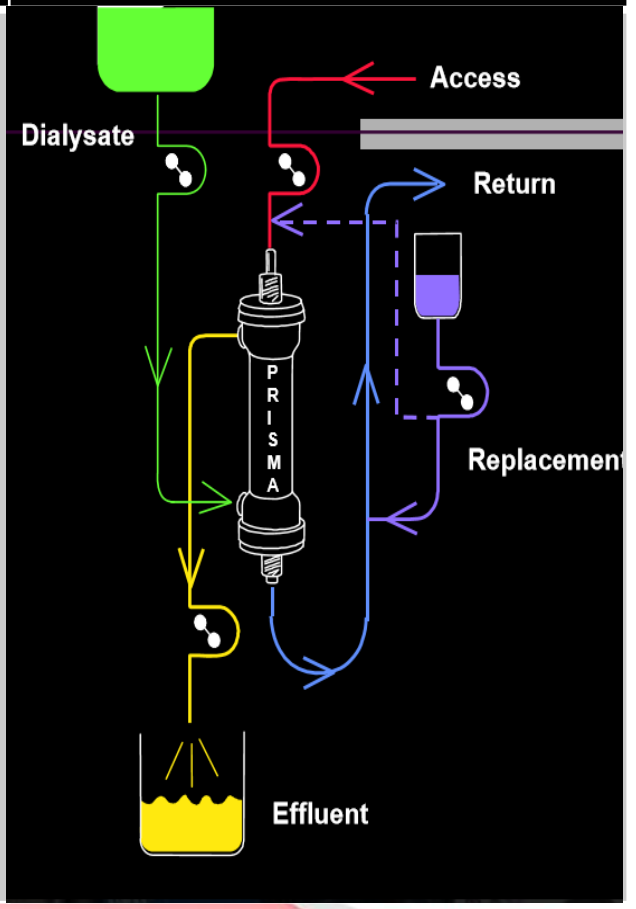
Continuous
veno-Venous
HemoDialysis



Volume overload +
hypoperfusion
Continues HD

CVVHDF

Continuous
veno-Venous
HemoDiafiltration



CRRT Orders

1. **Priming solution:** BW<15-20 kg: blood/ Albumin/FFP (<10Kg)
   BW> 20 kg: NS + 5000 U/L heparin
- 2. **BFR (blood flow rate):** 3 to 5 ml/kg/min
   (lower limit of 50 ml/min as much as 10 ml/kg/min)
- 3. **FRF (filter replacement fluid):** 30 to 40 ml/kg/hr
   BW>10 kg, normal saline at 5% of the FRF rate will run post-filter
- 4. **Dialysate rate:** 30 to 40 ml/kg/hr (2000 cc/1.73 m^2/hr) (30-60)
- 5. **UF rate:** 0-2 ml/kg/hr
- 6. **Filtration fraction:** less than 30%
- 7. **Anticoagulation:**
- **Heparin:** Bolus: 10-20 U/Kg then:10 (5-20) U/kg/hr
  to maintain APTT of **1.5–2.5** times the control value (25–35 s)
- **Citrate (RCA):** The KDIGO guidelines suggested using RCA rather than heparin in patients who do not have contraindications for citrate (Liver failure, Hypernatremia, calcium abnormality)

1. Priming

- **Priming solution:** BW<15-20 kg: blood/ Albumin/FFP

  In some study < 10 Kg

  BW> 20 kg: NS + 5000-10000 U/L heparin

  blood: (Risk of hypocalcemia, hyperkalemia, acidosis, bleeding)

- Blood to dilute 1:1 with sodium bicarbonate
- Calcium chloride 1 mL/kg of 100 mEq/mL
- Drop in platelet count and coagulation factors

2. BFR

- **BFR (blood flow rate):** 3 to 5 ml/kg/min

  (lower limit of 50 ml/min as much as 10 ml/kg/min)

- The maximum BFR is 400 mL/min/1.73 m^2 or:

  Neonates and infants: 10–12 mL/kg/min

  Children: 4–6 mL/kg/min

  Adolescents: 2–4 mL/kg/min

Body weight (kg)	<10	11–20	21–50 kg	>50
Blood flow rate (mL/min)	24–50	80–100	100–150	150–180

3. FRF / 4. DR

3. FRF (filter replacement fluid): 30 to 40 ml/kg/hr

BW>10 kg, normal saline at 5%

of the FRF rate will run post-filter

4. Dialysate rate: 30 to 40 ml/kg/hr (2000 cc/1.73 m^2/hr)

(30-60)

5. UF

UF rate: 0-2 ml/kg/hr

Fluid removal goals ranged from 1 to 3 mL/kg/h.

Liberation from CKRT was performed with a **diuretic bolus** followed by an infusion or a diuretic bolus alone.

6. FF

- **Filtration fraction:** less than 30% (25-35%)

$$FF\ (\%) = \frac{UFR \quad X \quad 100}{BFR \ X\ (1 - HCT)}$$

7. Anticoagulation

- **Heparin:** Regional unfractionated heparin infusion
- **Bolus: 10-20 U/Kg then:10 (5-20) U/kg/hr**
  - to maintain APTT of **1.5–2.5** times the control value (25–35 s)

- **Target :**
- activated partial thromboplastin time (APTT) of 40–55 seconds (1.5- to 2-fold of normal value) or,
- activated coagulation time (ACT) of 150–180 seconds.

- ACT and APTT were detected once per 4–6 hours.

- **Citrate (RCA):** The KDIGO guidelines suggested using RCA rather than heparin in patients who do not have contraindications for citrate (Liver failure, Hypernatremia, calcium abnormality)

Initial bolus is 20 U/kg (administer pre-filter).

Subsequent hourly continuous infusion (10–20 U/kg/h) is given to maintain APTT of **1.5–2.5** times the control value (25–35 s)

Adjust heparin infusion rate according to APTT as follows:

APTT (s)	Heparin infusion rate
50–80	No change
<50	Administer bolus of 10 U/kg, increase by 10 %, and recheck APPT in 1 h
>80	Hold heparin infusion by ½ h, decrease by 10 %, and recheck APPT in 1 h

Patients experiencing a rate of **clotted sessions >25% of total CRRT sessions** were considered as patients with “high clotting rate.”

Monitoring

ACT and APTT were detected once per 4–6 hours.

The hemofilter was changed:

- Every 24 hours
- When transmembrane pressure greater than 200 mm Hg, or
- When clotted

Clinical findings

The biochemical parameters in patients including

Lab tests parameters

The biochemical parameters in patients including:

- Lactate, Electrolytes, Acid base
- The ratio of the PaO_2 to the FIO_2 (PaO_2/FIO_2)
- Alanine transaminase (ALT), total bilirubin (TBIL)
- Serum creatinine (sCr), blood urea nitrogen (BUN)
- Inflammatory factors (TNF-α and interleukin-6), and the percent of immune cells (natural killer [NK] cells, cluster of differentiation [CD]19^+, $CD4^+$, and $CD8^+$)

CRRT Complications

Risks associated with intravascular lines:

- Hemorrhage
- Arteriovenous fistula formation
- Infection
- Thrombosis

Risks of the therapy itself:

- Electrolyte disturbances
- Clearance of trace elements or antibiotics
- Hypothermia
- Hypotension
- Hemolysis

The electrolyte and acid-base status should be monitored every 6 to 12 hours when starting CRRT. The interval may be increased to 12 to 24 hours if the condition remains stable after the first 24 to 48 hours

Nutrition

Whenever possible, **enteral nutrition** is preferred in critically ill patients.

However, if TPN is used for patients on CRRT, they should receive at least 2g/kg/day protein.

Discontinuation of CRRT

- Vasopressor cessation
- Increased UOP ≥ 500 ml/24 h (without diuretics)
- Hemodynamic stability
- Correction of fluid overload

and

- The possible need to shift to IHD due to imminent discharge from the ICU


حسبی
الله