CRRT PRACTICE GUIDE

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This is NOT meant to explain indications, physiology, etc. of CRRT! For details on that, contact Dr. Galvagno for some excellent reference articles (sgalvagno@anes.umm.edu). Also, see references below.

Typical Initial Settings:

- ✓ Blood flow: up to 180 mL/min
- ✓ Replacement: up to 4500 mL/hr
- ✓ Dialysate: up to 2500 mL/hr
- ✓ Ultrafiltration: up to 2000 mL/hr

Solutions

Primasate®- 5 L bag
Na^+ 140, K^+ 0, Cl^- 109.5, Ca^{2+} 3.5, Mg^+ 1, Lactate 3, $HCO3^-$ 32, glucose 0

Premixed Dialysate®-5 L bag
Na^+ 140, K^+ 2.0, Cl^- 117, Ca^{2+} 3.5, Mg^+ 1.5, Lactate 30, Glucose 100

Azotemia:

Increase your replacement fluid and/or dialysate flow rate

Hyponatremia:

Add 3% NaCl to your dialysate at 70 mL per 5 L bag

Hypernatremia:

Treat with peripheral D_5W (1L) or ½ NS as a background infusion

Potassium Management:

Serum K^+	What to add	1 L bag	5 L bag
> 5.5	0 mEq/L	None	None
4.5-5.5	3 mEq/L	7.5 mL	37.5 mL
< 4.5	4 mEq/L	10 mL	50 mL

pH Management:

Metabolic acidosis:

- ✓ Add $NaHCO_3$ in 100mL over 1 hour, IV, as needed
- ✓ Consider changing your replacement to D_5W (1L) plus 3 ampules of $NaHCO_3$

Metabolic alkalosis:

- ✓ Change your replacement solution to 0.9% NS with a sliding scale for potassium replacement

Calcium Management:

Hypercalcemia:

- ✓ Change to calcium free dialysate (bicarbonate based)
- ✓ Increase HCO_3 dialysate or replacement flow rate

Hypocalcemia:

- ✓ CaCl (10%) 10 ml/100mL 0.9% NS or D_5W over one hour, as needed
- ✓ Consider use of a premixed calcium infusion

Magnesium and Phosphate Management:

Hypomagnesemia:

- ✓ $MgSO_3$ (50%), 2 mL in 100 mL 0.9% NS or D_5W over one hour, as needed

Hypermagnesemia:

- ✓ Utilize same treatment as for hypercalcemia: Change to calcium free dialysate (bicarbonate based) and increase HCO_3 dialysate rate or replacement flow rate

Hypophosphatemia:

- ✓ Sodium phosphate (3 mmol/mL) 5 mL in 100 mL 0.9% NS IV over 2 hours, as needed, repeat as required for PO_3^- < 1.0 mg/dL

Hyperphosphatemia:

- ✓ Utilize same treatment as for hypercalcemia: Change to calcium free dialysate (bicarbonate based) and increase HCO_3 dialysate rate or replacement flow rate

Anticoagulation:

Heparin: 250-500 U/hr to start

For HIT, use argatroban, 0.5-1.0 mg/hr
Or citrate regional anticoagulation

Sample argatroban protocol:

1. Call hematology for approval / advice
2. 0.5-5 mL/hr; use lower dose (15 mcg/kg/hr) if in liver failure
3. Check aPTT every 12 hours

A few key CRRT papers:

1. Bellomo et al, NEJM 2009; 361(17): 1627-38.
2. Faber & Klein. Nursing Crit Care 2009; 14(4): 207-212.
3. Ghossein C, et al. International Anes clin 2009; 47(1): 15-24.
4. Stefan J. Chest 2007; 132: 1379-1388.
5. Thadhani R, et al. NEJM 1996; 334(22): 1448-1459.
6. VA/NIH trial. NEJM 2008; 359(1): 7-20.
7. Vissonneau C, et al. Lancet 2006; 379-85.
8. Tolwani, A. CRRT for AKI. NEJM 2012; 367: 2505-14.

Continuous Renal Replacement Therapy (CRRT)

"Cheat Sheet"

Indications for renal replacement

	Traditional	Other
A	**acidosis**	**Rhabdomyolysis**
E	**electrolyte abnormalities**	**Sepsis**
I	**intoxication**	
O	**fluid overload**	
U	**uremia**	

Types of CRRT

SCUF - Slow continuous ultrafiltration (removal 1-4 mL/min or 3-6 g/day of urea). No replacement fluid.

CVVH - Continuous veno-veno hemofiltration (greater than 1L/hr ultrafiltrate production). Requires replacement fluid.

CVVHD - Continuous veno-veno hemodialysis (24-30 g/day urea clearance). Requires dialysate.

CVVHDF - Continuous veno-veno hemodiafiltration (36-38 g/day urea clearance). Requires dialysate and replacement fluid.

Definitions

Ultrafiltrate (UF) - Fluid collected in the bag distal to the hemofilter.

Dialysate - Fluid instilled into filter counter-current to flow of the ultrafiltrate.

Effluent = UF + dialysate

Substitution/Replacement fluid - Fluid instilled pre or post-filter to replace ultrafiltrate volume.

Sieving coefficient (Sc) - Ability of substance to pass through filter (Sc=1 passes freely; Sc=0 unable to pass).

"Solute drag" - Free circulating, unbound solutes carried with water during ultrafiltration. Solutes bound to red blood cells or proteins are NOT cleared.

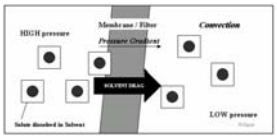
Qb - Blood flow rate (typically 150-300 mL/min).

QD - Dialysate flow rate (typically 1-3 L/hr).

Concepts

Filtration - *convective* clearance

occurs when water driven by hydrostatic or osmotic force is pushed through a membrane. Solutes that can pass easily through the membrane pores are swept along with the water ("solute drag").



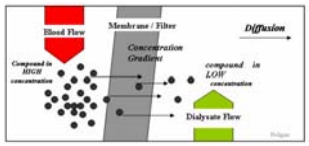
Convective clearance (urea) = UF (urea) X Quf / Plasma (urea)

Clearance is dependent on ***ultrafiltration*** production rate

UF (urea) = ultrafiltrate urea concentration (mg/dL), Quf = ultrafiltration production rate (mL/min), Plasma (urea) = plasma urea concentration (mg/dL).

Dialysis - *diffusive* clearance

occurs due to movement of solutes as the result of random molecular motion. If the solute molecule encounters a pore of sufficient size, the molecule will pass through the filter. Can occur in either direction.



Diffusive clearance (urea) = Dialysate (urea) X Qd / Plasma (urea)

Clearance is dependent on ***dialysate*** *infusion* rate

Dialysate (urea) = exiting dialysate urea concentration (mg/dL), Qd = dialysate flow rate (mL/min), Plasma (urea) = plasma urea concentration (mg/dL).

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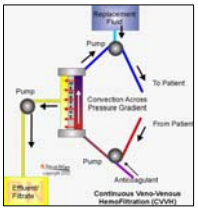

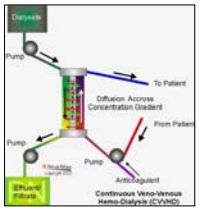

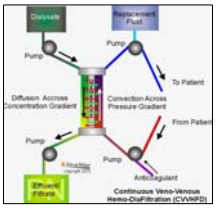

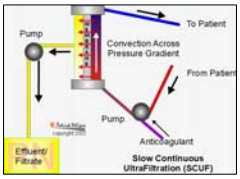

Comparison of Different CRRT Modalities

Modality	Urea Clearance (g/ Day)	Replacement Fluid / Dialysate	Middle Molecular Clearance
SCUF	1 - 4	No / No	+
CVVH	22 – 24	Yes / No	+ +
CVVHD	24 - 30	No / Yes	-
CVVHDF	36 - 38	Yes / Yes	+ + +

Clearance Table

Molecular size	Small solutes (< 300D)	Middle molecules (500-50,000D)	Low molecular weight proteins (5,000-50,000D)	Large proteins (> 50,000D)
Substances	Urea, creatinine, amino acids	Myoglobin, B12, vancomycin	Inflammatory mediators	Albumin
Clearance mechanism	Convection / diffusion	Convection	Convection + / - absorption	Convection

Anticoagulation Options

Type	Initiation	Monitor	Contraindications / Cautions
Heparin		Pre and post filter PTT	TBI, SCI, coagulopathy, HIT
Tri-Sodium Citrate		Pre and post-filter Ca^{++}	Hypernatremia, alkalosis, hypocalcemia

Initiation of CRRT

Select modality based on indication and goals of clearance/volume removal.

CVVH	CVVHD	CVVHDF	SCUF
ie. Fluid Management, Middle molecule clearance - oliguria and rhabdo	ie. Solute clearance - uremia	ie. Fluid Management, Solute and LMW protein clearance - sepsis and ARF	ie. Fluid Management - CHF
1. Set Qb 2. Set substitution flow 3. Select substitution fluid (pre or post filter) 4. Set UF rate 5. Select A/C	1. Set Qb 2. Set QD 3. Select dialysate 4. Set UF rate 5. Select A/C	1. Set Qb 2. Set substitution flow 3. Select substitution fluid 4. Set QD 5. Select dialysate 6. Set UF rate 7. Select A/C	1. Set Qb 2. Set UF rate 3. Select A/C

References:

Shillinglaw and Reynolds. Continuous renal replacement therapy and ultrafiltration. In: Complications in Trauma and Critical Care, WB Saunders 1996, Chapter 18.

Mann. Continuous renal replacement therapies: an update. Am J Kid Dis. 1998;32:185-207.

Ronco, Bellomo, and Ricci. Continuous renal replacement therapy in critically ill patients. Nephrol Dial Transplant. 2001;16:S67-72.

Ricci, Ronco, Bachetoni, et al. Solute removal during continuous renal replacement therapy in critically ill patients: convection versus diffusion. Critical Care. 2006;10:R67.

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