RENAL REPLACEMENT THERAPY by Nick Mark MD

ONE onepagericu.com @nickmmark Link to the most current version →

DEFINITION:

Renal Replacement Therapies (RRT) are used in patients in the IUC with renal failure to ***remove excess fluid*** or to ***clear the blood of toxins*** (such as urea or potassium).

· **Clearance** (K) is the volume of blood cleared of a solute (typically urea) per time. Clearance depends on **Blood flow** (Q_B), **dialysate flow** (Q_D) and the **dialyzer**. There are two primary mechanisms involved:

· **Diffusion** (with **dialysis**) clears smaller molecules (<200 D), while **convection** (with **UF**) clears small & medium sized (< 50kD) molecules.

INDICATIONS:

Urgent/emergency RRT may be indicated for conditions *refractory to medical therapy*:

· **A: Acidosis** (usually severe metabolic)

· **E: Electrolyte derangements** (hyperkalemia, hypercalcemia, etc)

· **I: Intoxications** (APAP, Barbiturates, Lithium, carbamazepine, metformin, methanol, salicylates, thallium, theophylline, valproate, etc); see ExTRIP guidelines

· **O: Fluid Overload** (pulmonary edema refractory to diuretics, uncontrolled hypertension, etc). Volume removal may also hasten liberation from ventilation.

· **U: Symptomatic Uremia** (causing severe altered mental status, uremic pericarditis, bleeding diathesis, etc)

COMPONENTS OF A HEMODIALYSIS CIRCUIT & PARAMETERS SET:

ULTRAFILTRATION (UF) is the filtration of water from the blood, driven by the transmembrane pressure (TMP) gradient between the blood & effluent. TMP can be titrated by adjusting the effluent pump & pressure.

$$UF \propto TMP \quad TMP = \frac{P_{filter} + P_{return}}{2} - P_{effluent}$$

Ultrafiltration (UF) provides clearance by **convection** (also called solute drag) removing small & medium sized molecules.

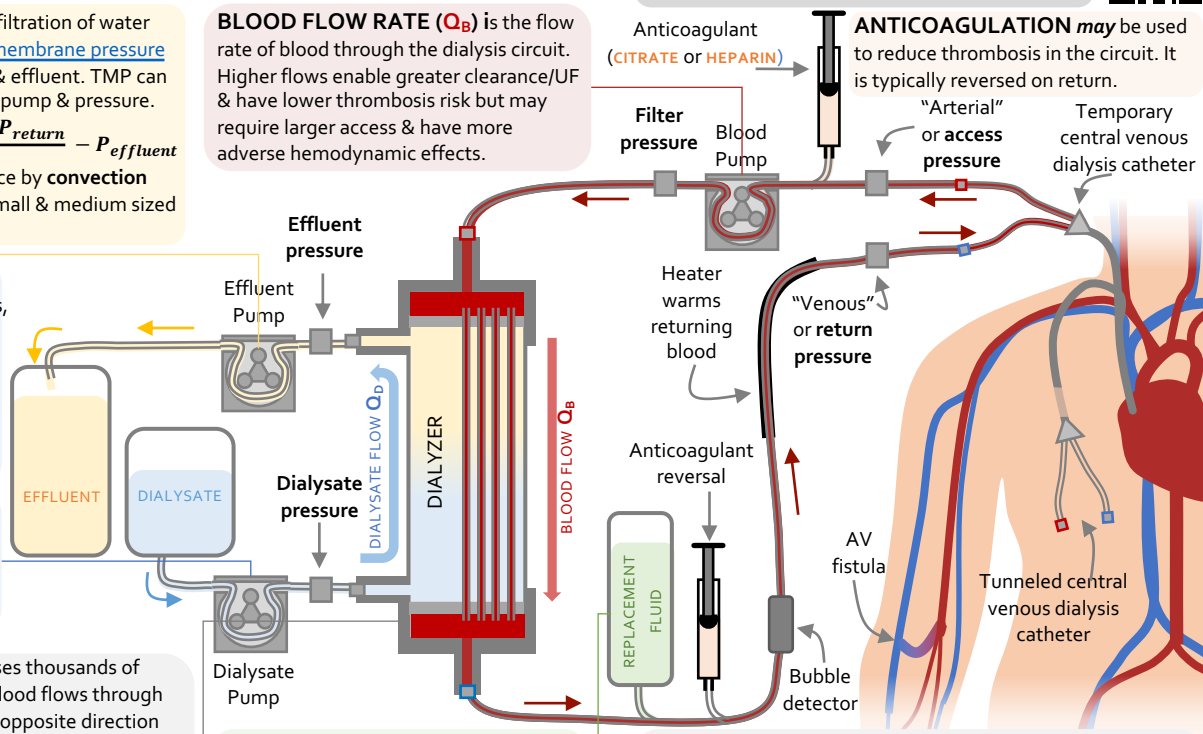
DIALYSATE SOLUTION is an isotonic fluid containing electrolytes, bicarbonate/acetate, glucose, & sometimes other small molecules. The dialysate is chosen to match serum osmolality & to correct any blood chemistry abnormalities; e.g:

$$K_{serum} + K_{dialysate} = 7\ mEq/L$$

DIALYSATE FLOW RATE (Q_D) is a countercurrent flow of dialysate through the dialyzer. Higher flow rates enable greater clearance of small molecules via **diffusion**.

DIALYZER is rigid case that encloses thousands of semi-permeable polymer tubules. Blood flows through the tubules & **dialysate** flows in the opposite direction outside (countercurrent). Dialyzers differ in surface area, hydraulic permeability (**KUF**), permeability to medium sized molecules (**flux** of β2 microglobulin), & permeability to small molecules diffusion (**mass transfer coefficient**)

BLOOD FLOW RATE (Q_B) is the flow rate of blood through the dialysis circuit. Higher flows enable greater clearance/UF & have lower thrombosis risk but may require larger access & have more adverse hemodynamic effects.



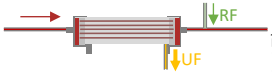
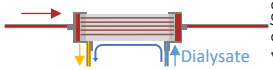
REPLACEMENT FLUID (RF) can be used to restore fluid volume removed by UF in the dialyzer. Replacement fluid can be given **pre-** or **post-dialyzer**.

ANTICOAGULATION *may* be used to reduce thrombosis in the circuit. It is typically reversed on return.

VASCULAR ACCESS can be *permanent* (such as an **AV fistula** or an **AV graft**) accessed using needles, *semi-permanent* (a **tunneled CVC),** or *temporary* (such as a **non-tunneled CVC**). NB: The "arterial" (red) side describes blood coming out of the patient; it does NOT mean that it comes out of an artery.

MODALITIES OF RRT IN THE ICU:

	IHD (Intermittent HD)	SLEDD (Sustained low efficiency daily dialysis)	CRRT (Continuous renal replacement therapy)
Description	3-5 hr session using **standard HD machine**	~12 hr session using **standard HD machine**	24 hr (continuous) session using a **CRRT machine**
Logistics	Typically done by dialysis RNs Requires fresh water & drain connections		Typically done by CCRNs Uses sterile fluid bags
Vascular Access	Fistula/Graft or CVC	Usually requires CVC	Requires CVC
QB / QD	> 300 ml/min > 500 ml/min	~ 200 ml/min 100-200 ml/min	< 200 ml/min <50 ml/min (depends on mode)
Clearance	Highest; ideal for hyperK or toxins	Moderate	Low; ideal for slower correction of abnormalities & fluid removal
Hemodynamics	**Hypotension** common	Causes less **hypotension**	Causes the least **hypotension**
Other risks	Risk of disequilibrium syndrome	Risk of hypoPhos, unclear med pharmacokinetics	Thrombosis risk, immobility, higher cost

CRRT Mode	Description	Schematic
SCUF	Slow continuous UF; UF removes fluid but provides almost no clearance and does not correct pH; no replacement fluid required. Corrects volume overload **only**.	
CVVH (a.k.a. CVVHF)	Continuous venovenous **hemofiltration**. Provides ***convective*** clearance by filtering a large volume of blood; Replacement fluid restores volume lost. Corrects uremia, lytes, pH and can remove volume.	
CVVHD	Continuous venovenous **hemodialysis**. Provides ***diffusive*** clearance by running **dialysate** opposite blood flow. No replacement fluid used. Gently corrects uremia, lytes, pH	
CVVHDF	Continuous venovenous **hemodiafiltration**. High clearance achieved using both **UF** & **dialysate** flow (both ***convection*** & ***diffusion***). Replacement fluid used. Allows fluid removal and correction of electrolyte/pH. Good for toxin removal.