Hemodialysis; Types and applications

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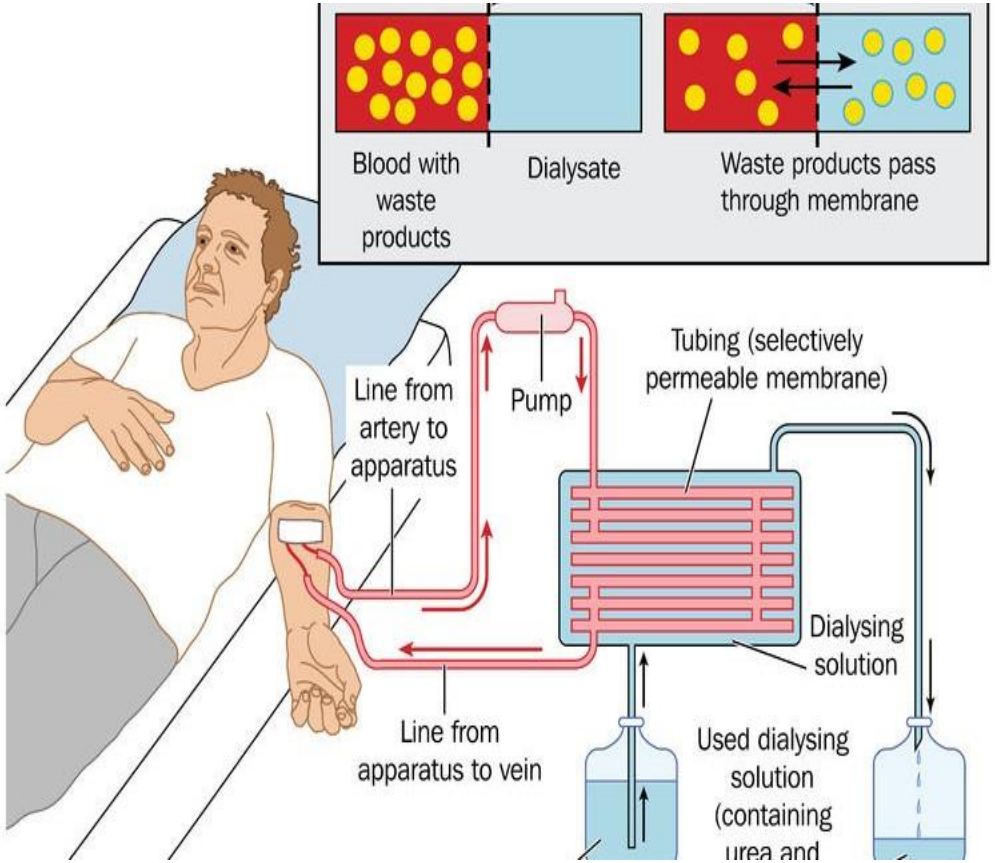
Outlines

- Dialysis
- Intermittent Hemodialysis
- Continuous Renal replacement therapies
- Slow low efficient dialysis
- Hemoperfusion

Hemodialysis

- Dialysis is defined as the diffusion of molecules in solution across a semipermeable membrane along an electrochemical concentration gradient

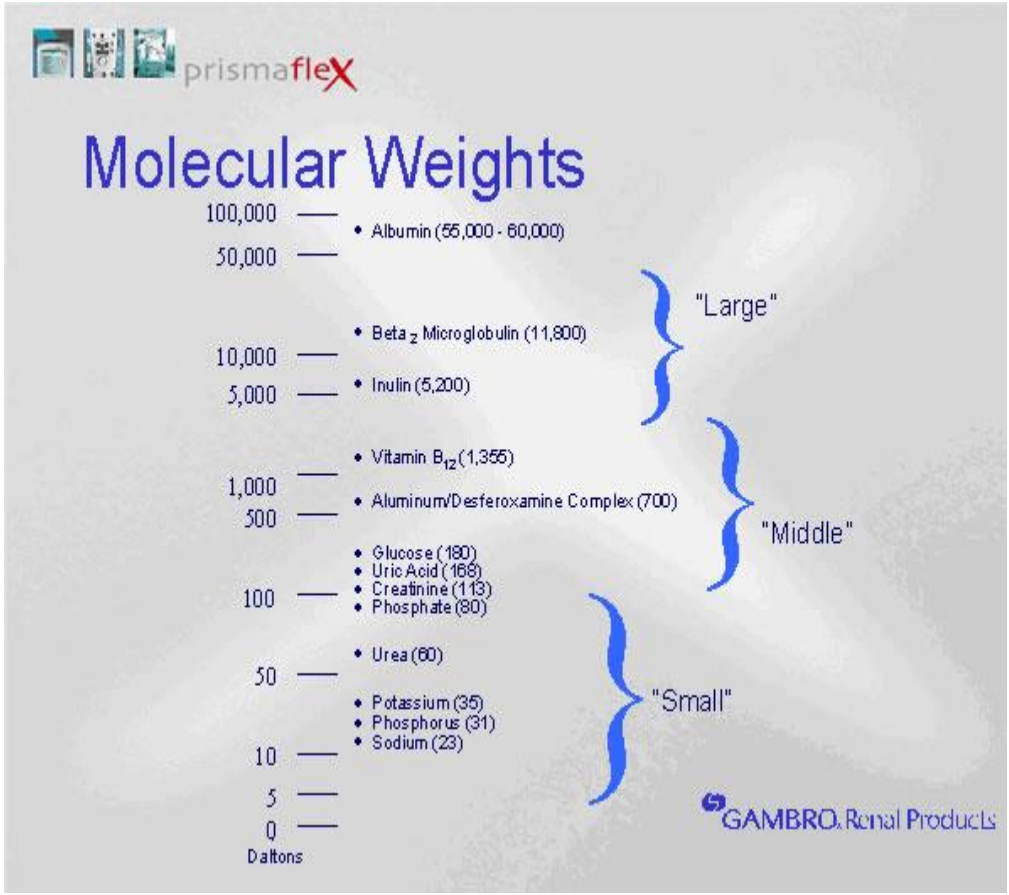


Hemodialysis

- The primary goal of hemodialysis is to restore the intracellular and extracellular fluid environment that is characteristic of normal kidney function.
- This is accomplished by the transport of solutes such as urea from the blood into the dialysate and by the transport of solutes such as bicarbonate from the dialysate into the blood

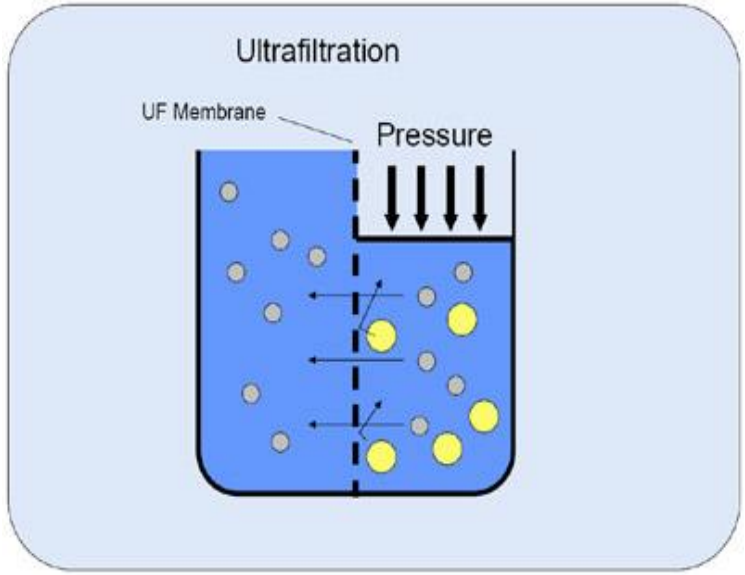
Hemodialysis

Small molecules, such as urea, diffuse quickly, whereas compartmentalized and larger molecules, such as phosphate, β2-microglobulin, and albumin, and protein bound solutes, such as p-cresol, diffuse much more slowly



- In addition to diffusion, solutes may pass through pores in the membrane by means of a convective process driven by hydrostatic or osmotic pressure gradients — a process called ultrafiltration.

- During ultrafiltration, there is no change in solute concentrations; its primary purpose is the removal of excess total body water.



Dialysis in acute setting

- Refractory fluid overload
- Severe hyperkalemia (plasma potassium concentration >6.5 mEq/L) or rapidly rising potassium levels
- Signs of uremia, such as pericarditis, encephalopathy, or an otherwise unexplained decline in mental status
- Severe metabolic acidosis (pH <7.1)
- Certain alcohol and drug intoxications

Dialysis in chronic setting

- Absolute indications

- Uremic pericarditis or pleuritis
- Uremic encephalopathy

Dialysis in chronic setting

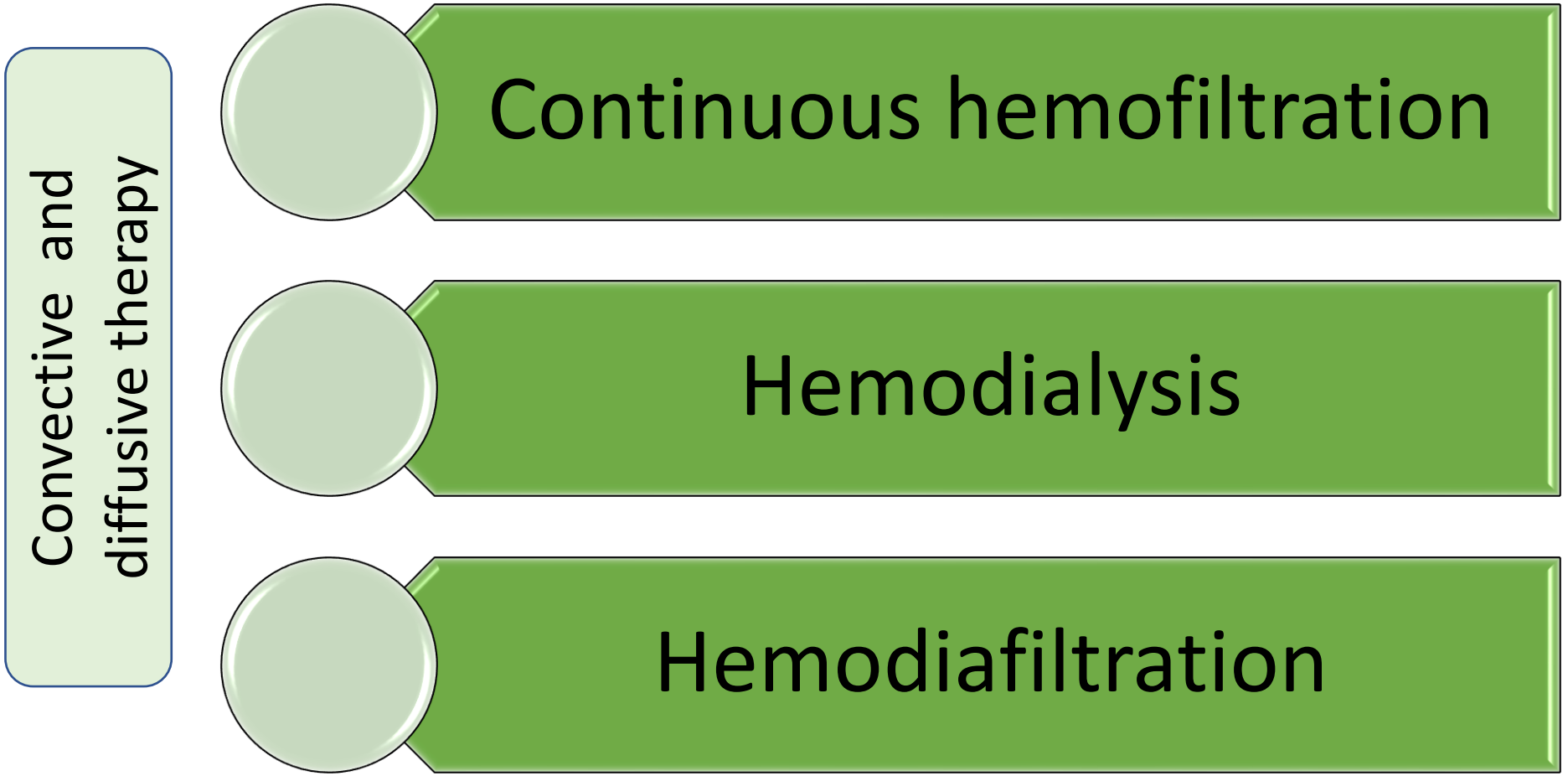
- Common indications

- Declining nutritional status
- Persistent or difficult to treat volume overload
- Fatigue and malaise
- Mild cognitive impairment
- Refractory acidosis, hyperkalemia, and hyperphosphatemia

OPTIMAL MODALITY

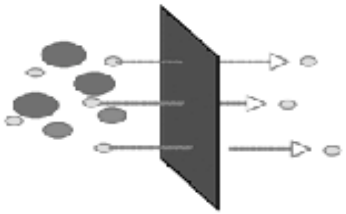
- Intermittent hemodialysis (IHD)
- Continuous Renal replacement therapy (CRRT)
- Hybrid therapies such as sustained low-efficiency hemodialysis (SLED)

Continuous Renal replacement therapies versus intermittent hemodialysis



Convective VS Diffusive

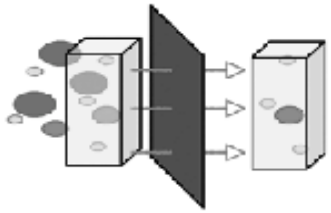
Diffusion is solute transport across a semi-permeable membrane – molecules move from an area of higher to an area of lower concentration



Best for small molecule clearance

Hemodialysis

Convection is a process where solutes pass across the semi-permeable membrane along with the solvent ("solvent drag") in response to a positive transmembrane pressure



Effectiveness less dependent on molecular size

Hemofiltration

Superior clearance of middle- and larger-molecular-weight molecules

CRRT modality

- Indications to perform RRT in AKI are the same for all modalities
- BUT the choice of modality might differ

- Major indication: hemodynamic instability
- Hypotension: less common with CRRT (although can still occur) because the rates of fluid and solute removal are slower than with IHD

CRRT

- Other indications:

Hemodynamically unstable patients who require ongoing, large-volume fluid administration, such as multiple IV medications, or TPN.

- CRRT is a continuous therapy, the net solute removal over 48h is higher than with IHD, despite the lower rate.

CRRT

- Other indications:

Is preferred to IHD in acute brain injury or other causes of increased ICP who have AKI

- IHD ⇒ Decrease in mean arterial pressure ⇒ Compensatory cerebral vasodilation ⇒ IHD ⇒ Rapid removal of urea ⇒ Shift of water to the intracellular space ⇒ Worsen cerebral edema

Indications for CRRT

- In critically ill patients with renal failure and hemodynaemic instability
- For patients in whom continuous removal of volume or toxic substance is desirable (as in septic shock , AMI , severe GI bleeding ,ARDS or condition with or at risk for cerebral edema ….)

IHD

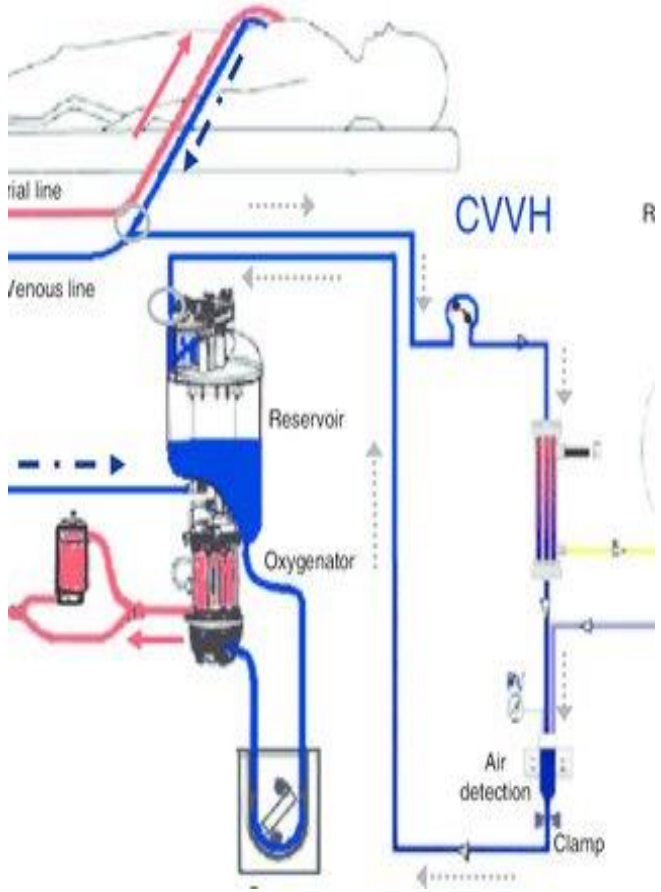
- May be better for the treatment of patients with severe hyperkalemia (ie, ECG changes that are refractory to calcium supplementation), even if the patient requires vasopressors during the treatment

Which CRRT modality is preferred?

- No specific CRRT modality has been shown to provide better outcomes.
- In most cases, the choice of CRRT modality within individual institutions depends on availability and the expertise of the clinician.

Continuous venovenous hemofiltration (CVVH)

- Uses hydrostatic pressure to induce the filtration of plasma water across the hemofilter membrane.
- Solutes are removed entirely by convection.
- Dialysate fluid is not used



Continuous venovenous hemofiltration (CVVH)

- The ultrafiltration flow rate is high (20 to 25 mL/kg/hour)
- Replacement fluid must be given to prevent volume depletion.
- The amount of replacement fluid that is given is determined by the net volume removal that is desired.

Continuous venovenous hemofiltration (CVVH)

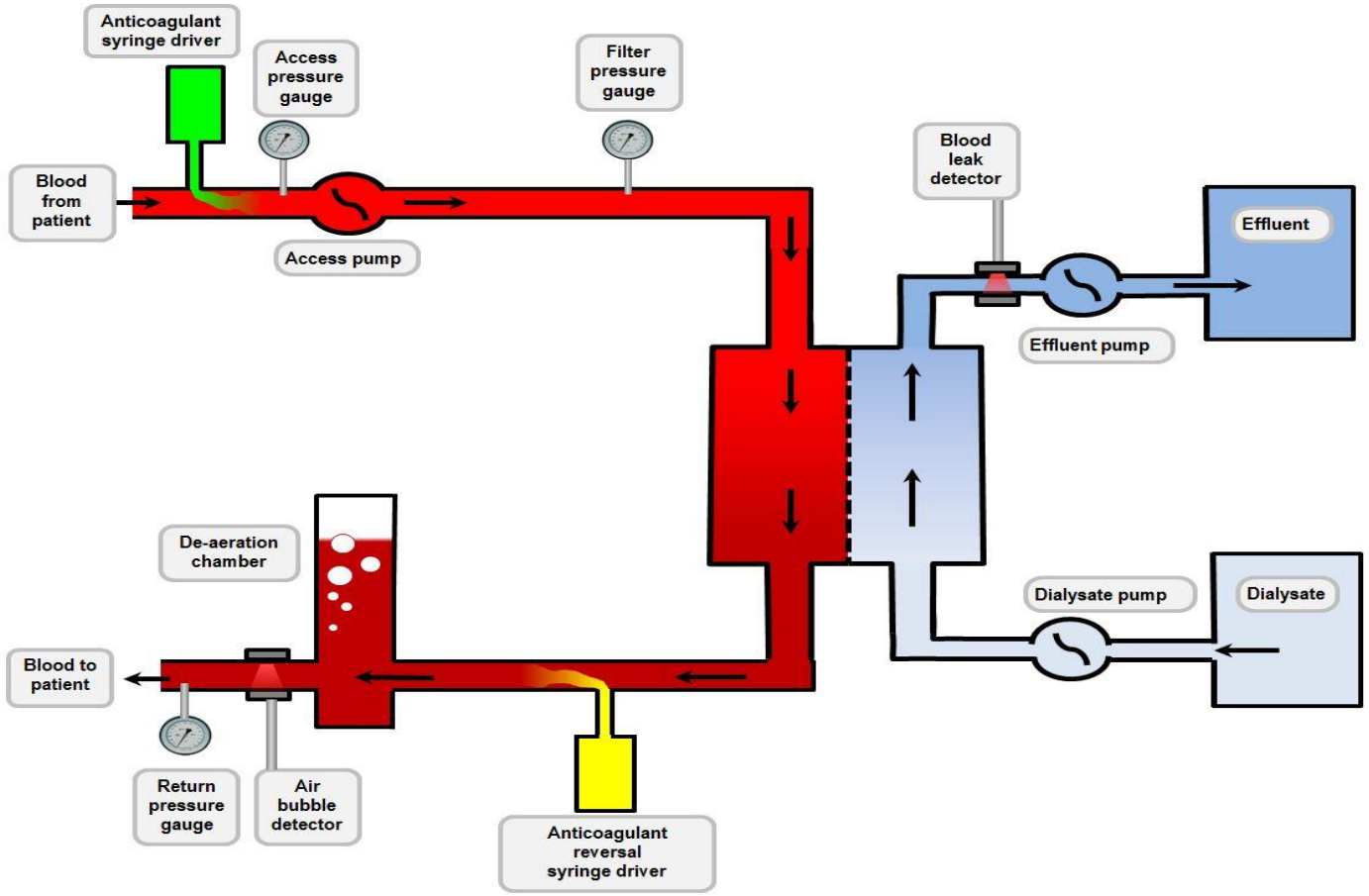
- Small- and middle-molecular-weight molecules such as urea and electrolytes, are removed in roughly the same concentration as plasma water.
- Therefore no change in the plasma concentrations of these solutes by hemofiltration.
- However, the administration of substitution fluid lowers by dilution the plasma concentrations of solutes such as urea and creatinine that are not present in the substitution fluid.

IHD vs CVVH

IHD	CVVH
Advantages	
Short duration Cheap Less labor-intensive	Hemodynamic stability Better removal of cytokines
Disadvantages	
Rapid hemodynamic change Technically sophisticated	Continuous anticoagulation Patient immobility Intensive nursing requirement Increased expense

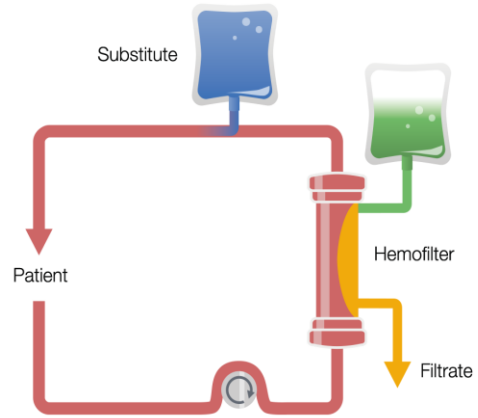
Continuous venovenous hemodialysis (CVVHD)

- Primarily removes solute by diffusion
- Dialysate fluid is used.
- Dialysate fluid is run countercurrent to the direction of blood flow at a rate of 1 to 2 L/hour.



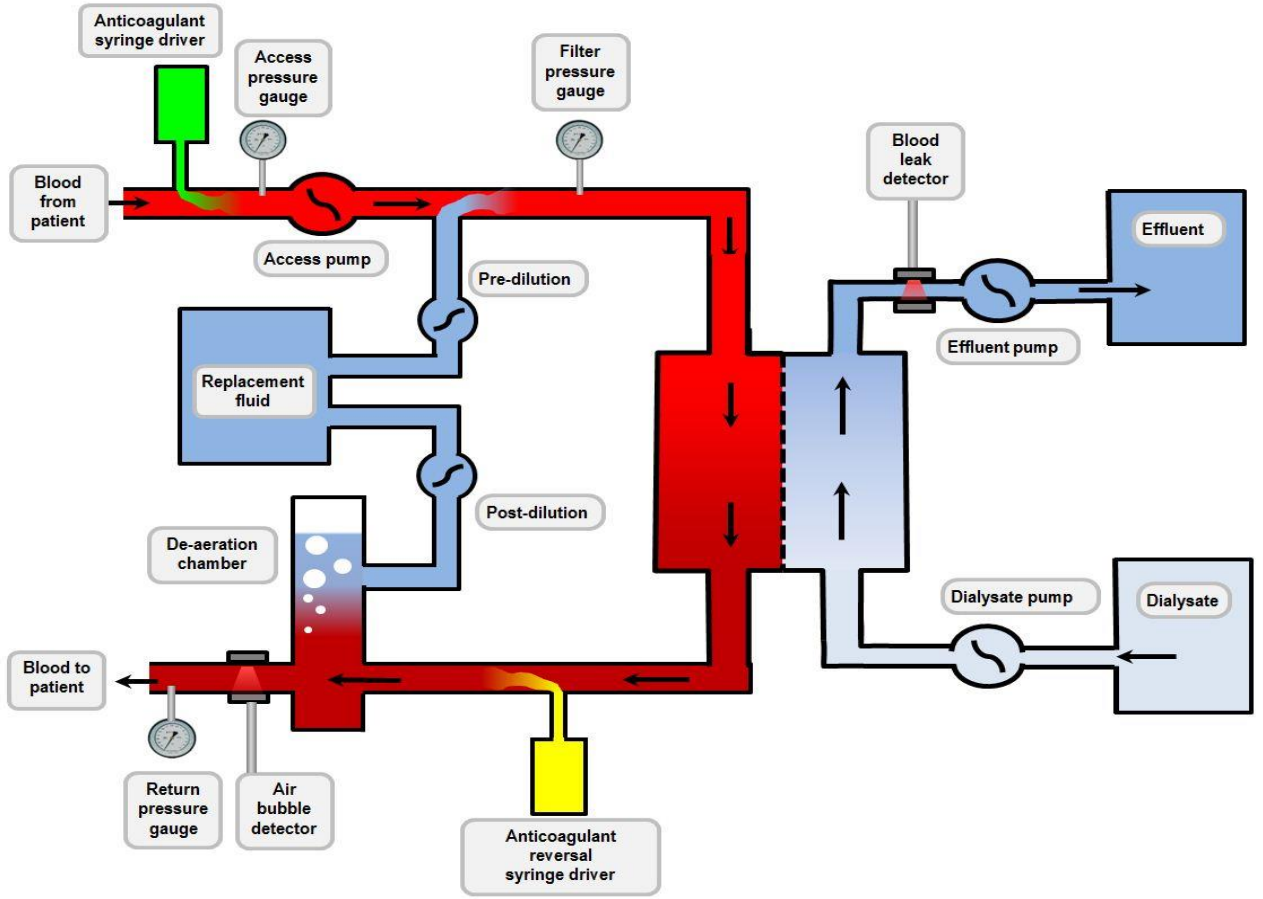
Continuous venovenous hemodialysis (CVVHD)

- The ultrafiltration rate is generally only 2 to 8 mL/min
- The dialysate flow rate is 20 to 25 mL/kg/hour.



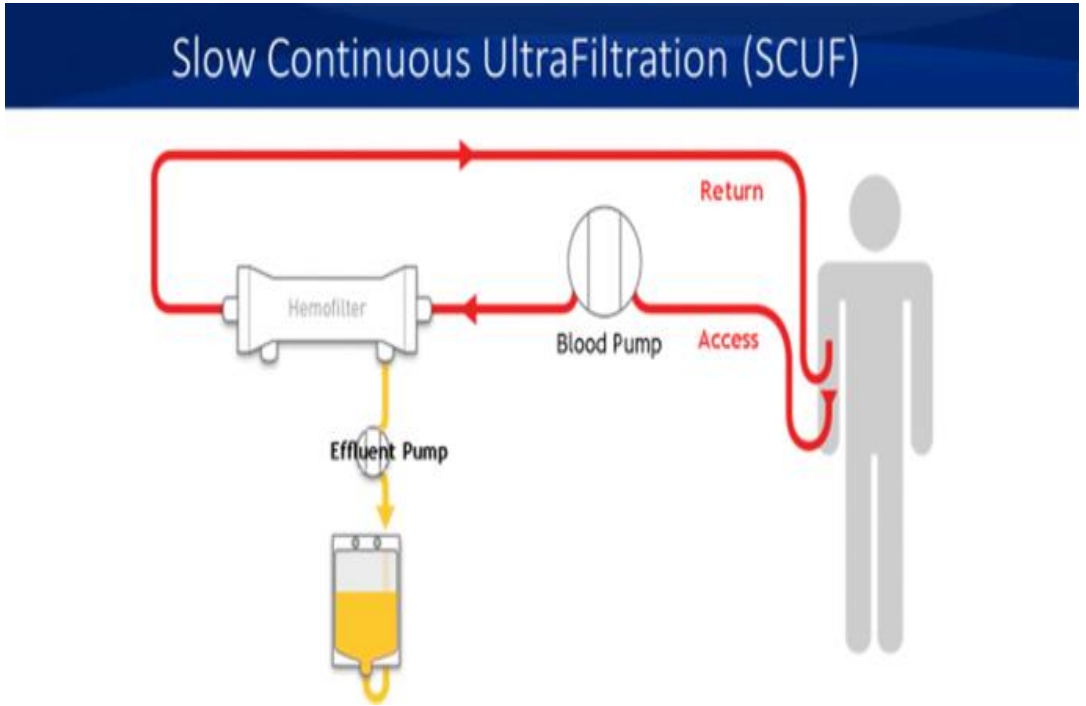
Continuous venovenous hemodiafiltration (CVVHDF)

- Combines diffusion with convection
- Infusions of both replacement fluid and dialysis fluid.
- The ultrafiltration volume is variable, and replacement fluid must be given to maintain euvolemia.



Slow continuous ultrafiltration (SCUF)

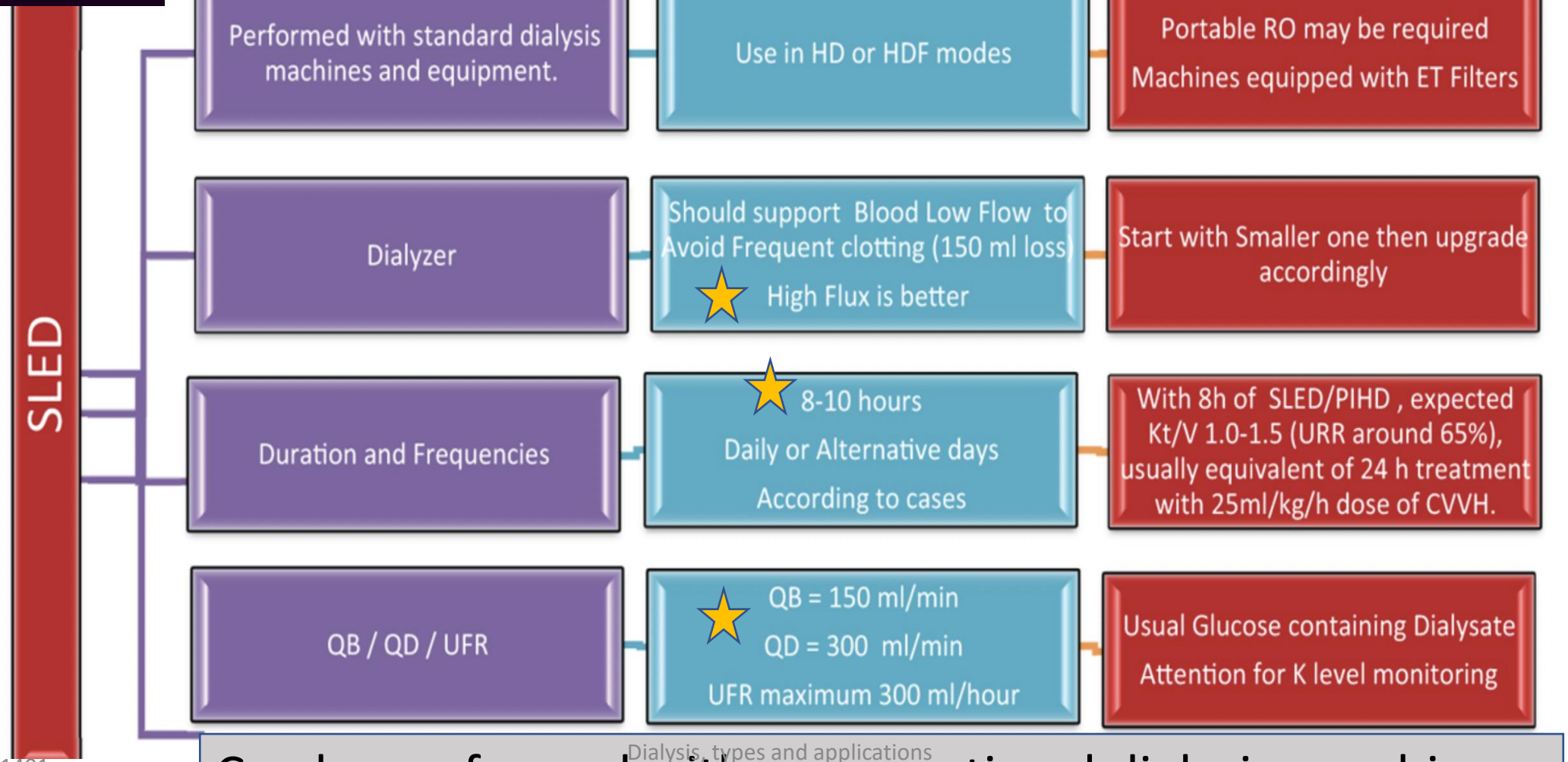
- Used to treat isolated fluid overload.
- SCUF is not useful in patients who are uremic or hyperkalemic, because solute removal is minimal
- SCUF can safely remove up to 8 L of fluid/day
- Neither replacement fluid nor dialysate fluid is used



Slow continuous ultrafiltration (SCUF)

- Convective solute loss is limited since the ultrafiltration rate is low compared with CVVH.
- There is no diffusive solute loss since dialysate fluid is not used.
- The blood flow is generally 100 to 200 mL/min and the ultrafiltration rate 2 to 8 mL/min.

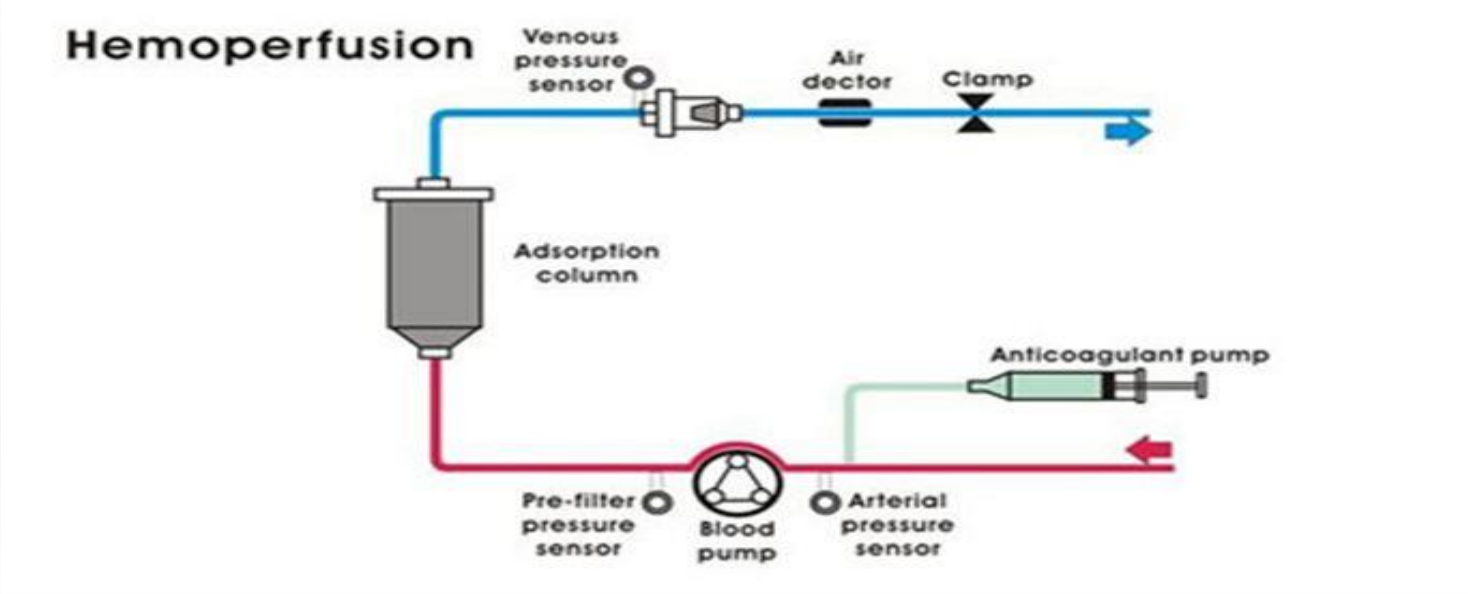
Slow Low Efficiency Dialysis (SLED)



Can be performed with a conventional dialysis machine

What is hemoperfusion?

- the passage of blood through a column containing adsorbent particles
- The particles are typically activated charcoal or resin



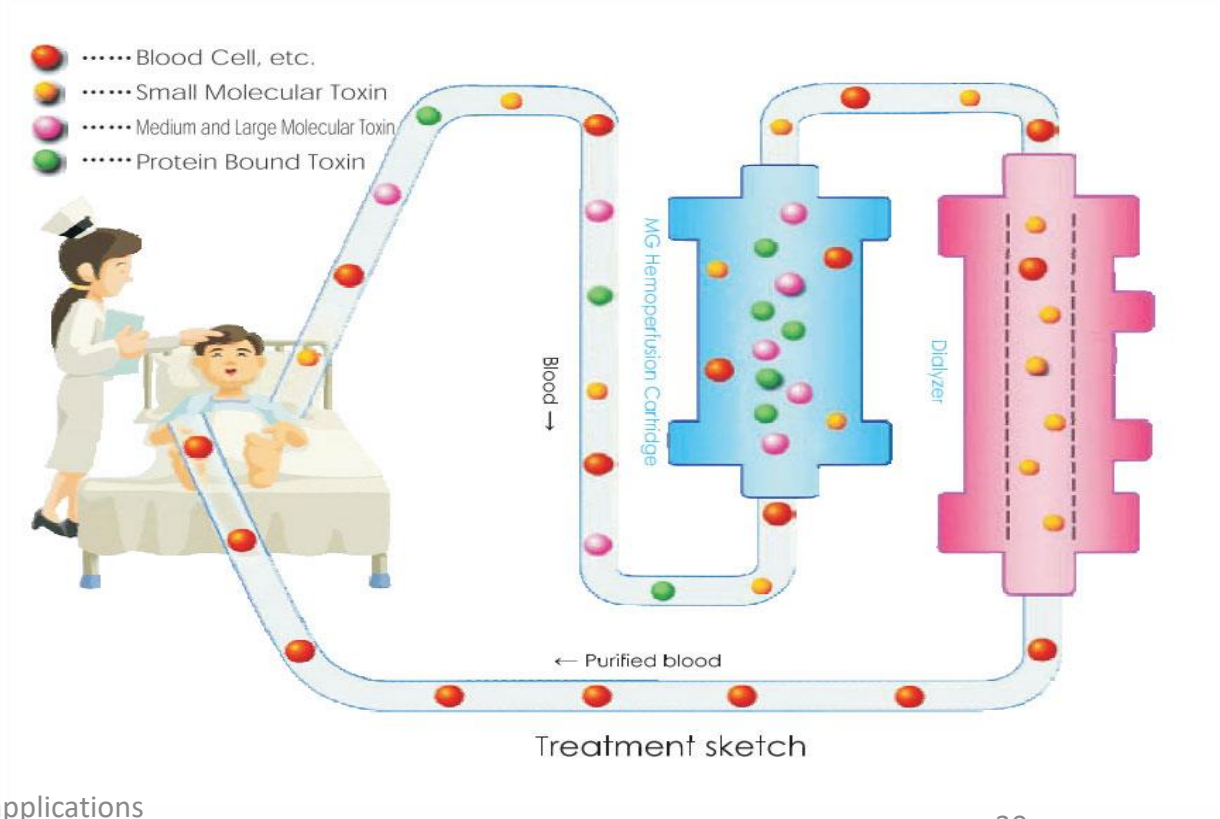
Muirhead, EE, Reid, AF. Resin artificial kidney. Lab Clin Med 1948; 33:841.

Hemoperfusion

- A technique in which the sorbent is placed in direct contact with blood in an extracorporeal circulation
- A peristaltic pump via blood lines

circulates blood through

the sorbent cartridge.



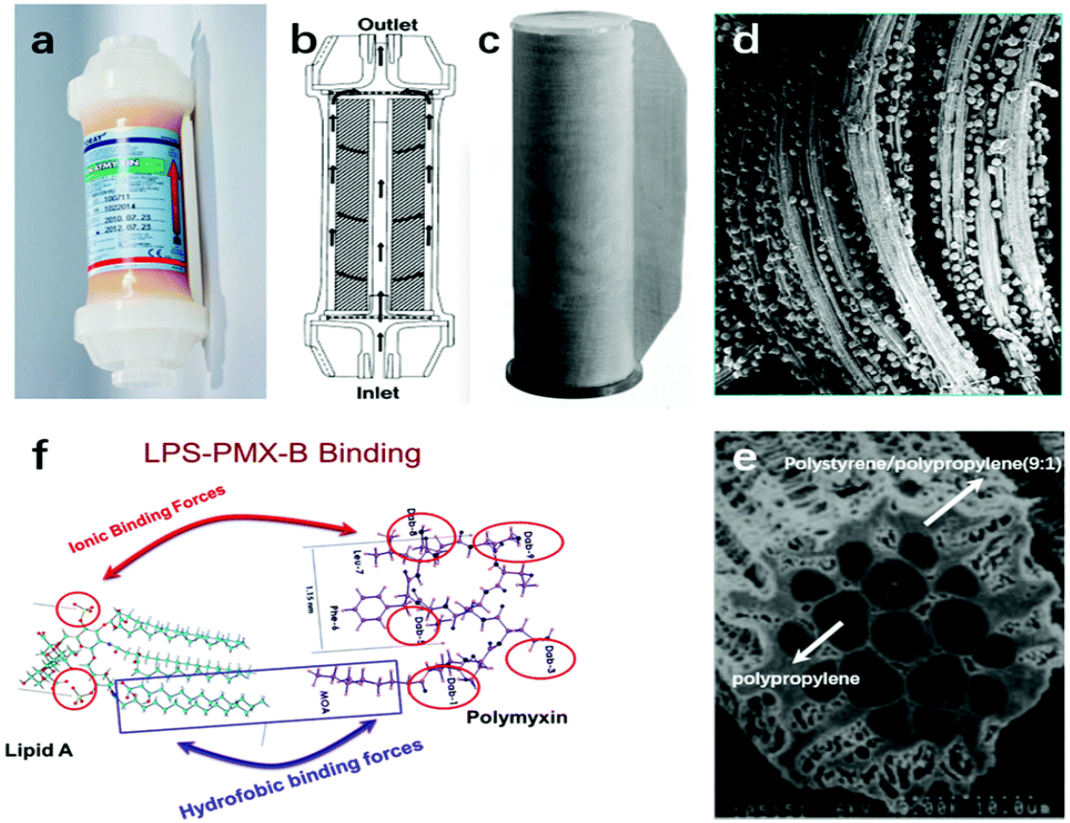
Treatment sketch

Hemoperfusion

- The HP circuit is simpler than one used for hemodialysis but requires adequate anticoagulation and a very biocompatible sorbent because there is a direct contact between blood and sorbent material
- Charcoal has a high adsorbing capacity, especially for relatively hydrophobic, low-molecular-weight solutes that are retained in case of kidney or liver failure.

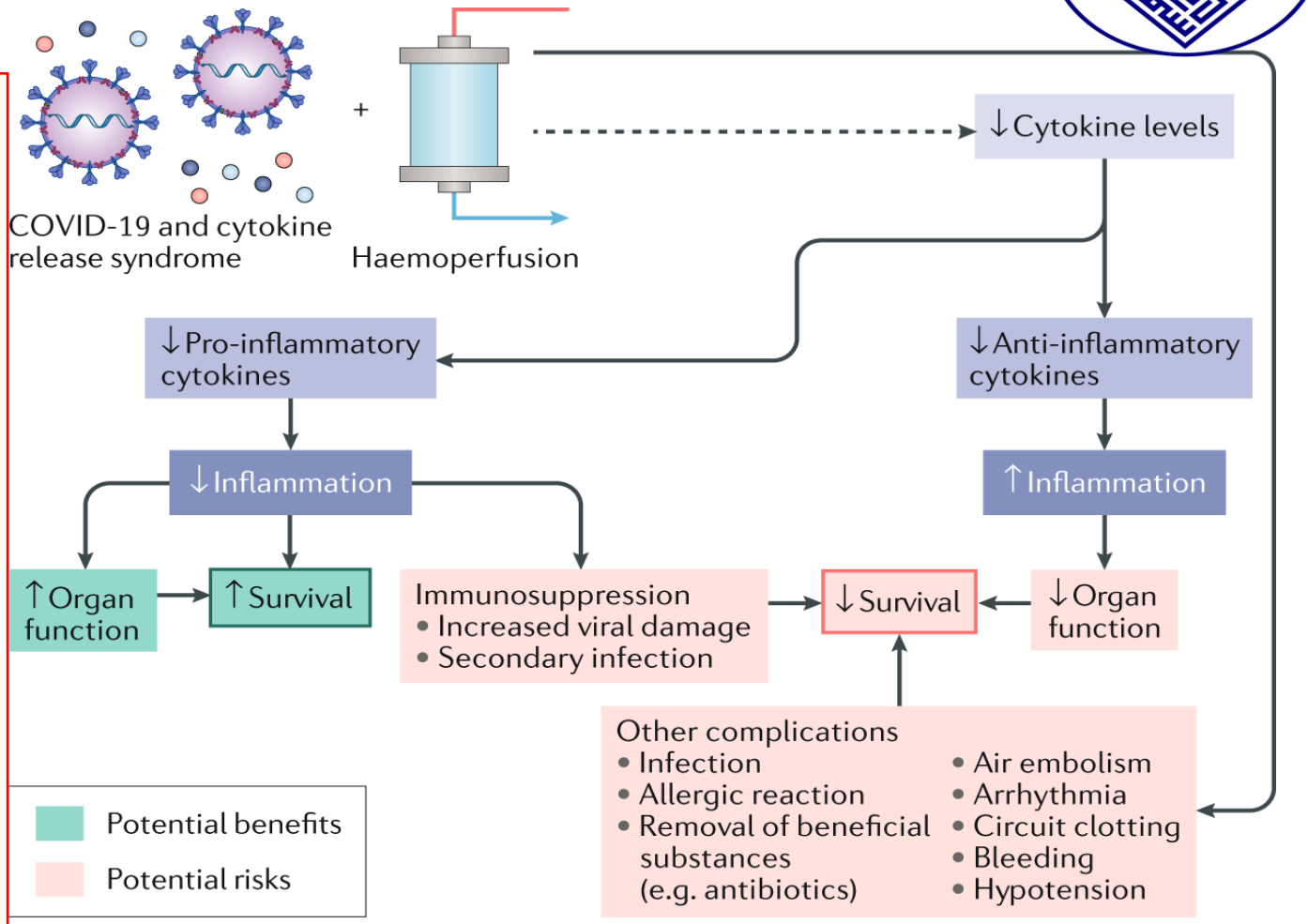
Hemoperfusion

- Synthetic polymers with remarkable capacity of adsorption have been made available for clinical HP.
- The pores on the surface of the granules have been widened so that size exclusion has become a minor issue.



Hemoperfusion

- ✓ Because of these recent advances, sorbent units are available for direct HP and have been demonstrated to be efficient in removing poisons, bilirubin, cytokines, or even endotoxin.



Hemoperfusion indications

- Removal of lipid-soluble, highly protein-bound toxins (ie, poisoning)
  - Paraquat compared, Barbiturates, Theophylline, Valproic acid, Carbamazepine, Amanita mushrooms, Aluminum after chelation with deferoxamine
- Removal of cytokines in septic patients
- Removal of antibodies and antibody-antigen complexes in autoimmune disorders
- Removal of hepatic toxins in liver failure

Take home message

- Dialysis is defined as the diffusion of molecules in solution across a semipermeable membrane.
- CRRT indications: hemodynamic instability, Hemodynamically unstable patients who require ongoing, large-volume fluid administration, acute brain injury or other causes of increased ICP who have AKI.
- Hemoperfusion: A technique in which the sorbent is placed in direct contact with blood in an extracorporeal circulation

Thanks for your attention