Hemodialysis; Types and applications

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Outlines

Dialysis

Intermittent Hemodialysis

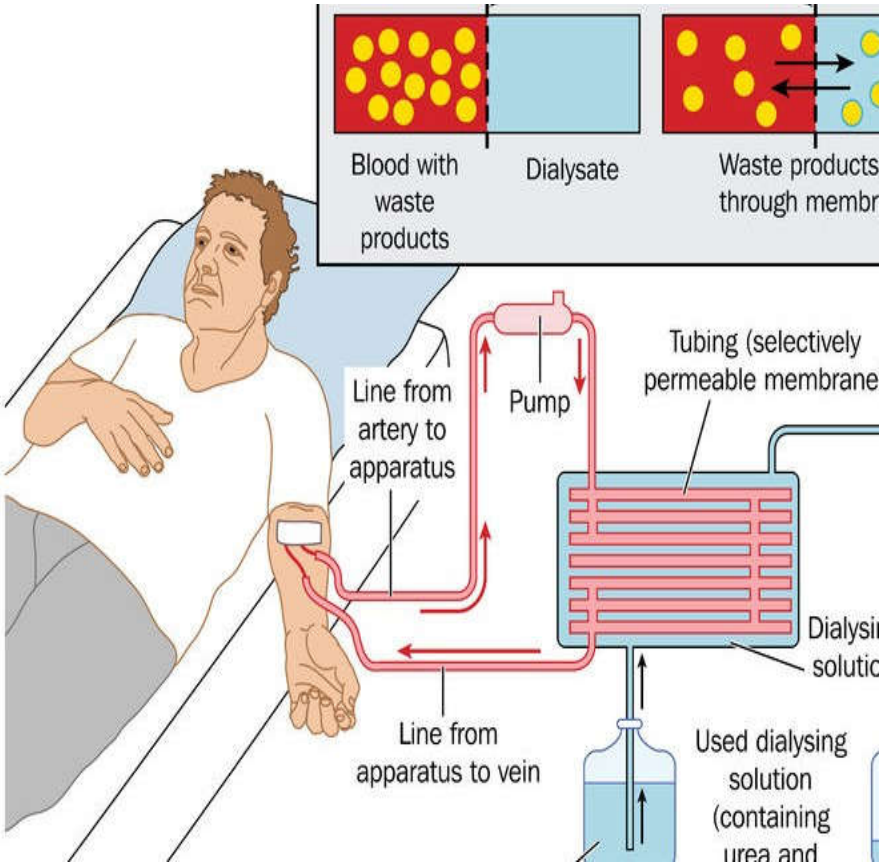
Continuous Renal replacement therapies

Slow low efficient dialysis

Hemoperfusion

Hemodialysis

ialysis is defined as the diffusion of
nolecules in solution across a
emipermeable membrane along an
lectrochemical concentration gradient



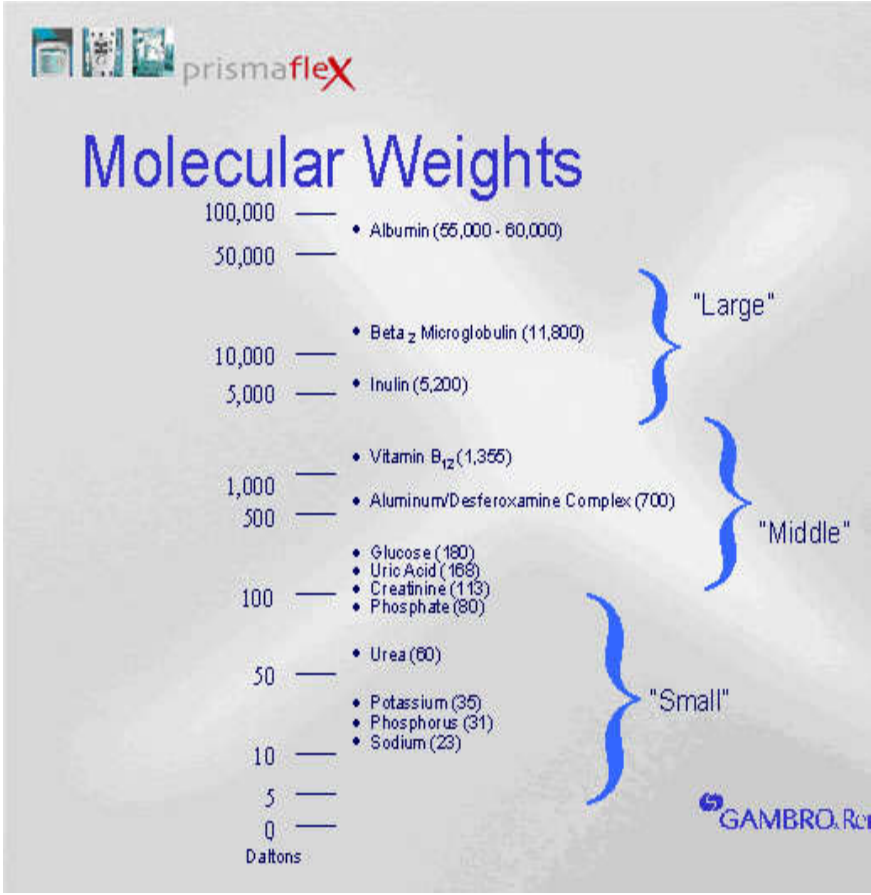
Hemodialysis

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

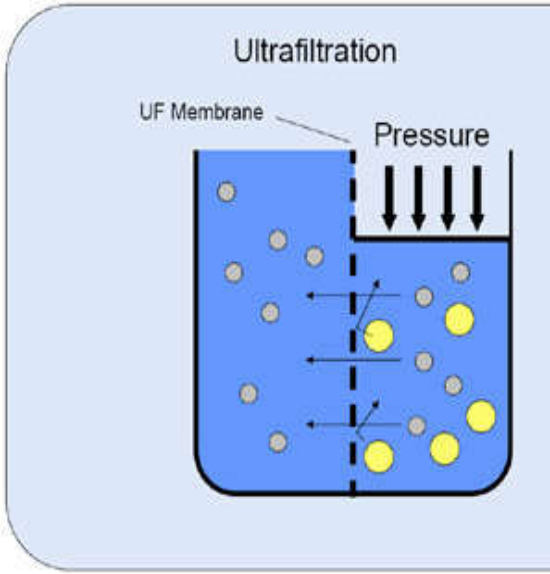
Hemodialysis

ll molecules, such as urea, diffuse
kly, whereas compartmentalized and
er molecules, such as phosphate, β2-
oglobulin, and albumin, and protein
nd solutes, such as p-cresol, diffuse
h 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) o
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)

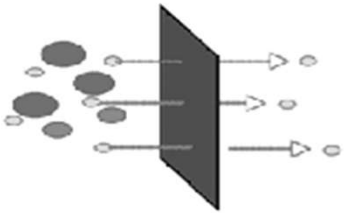
Continuous Renal replacement therapies versus intermittent hemodialysis

Convective and diffusive therapy

- Continuous hemofiltration
- Hemodialysis
- Hemodiafiltration

Convective VS Diffusive

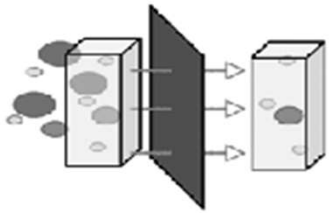
Diffusion is solute transport across a semi-permeable membrane – molecules move from an area of higher to an area of lower concentration



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

ior
nce of
e- and
-molecular-
t 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

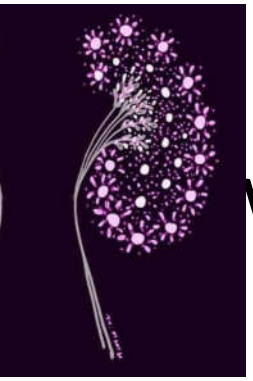
Indications for CRRT

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.

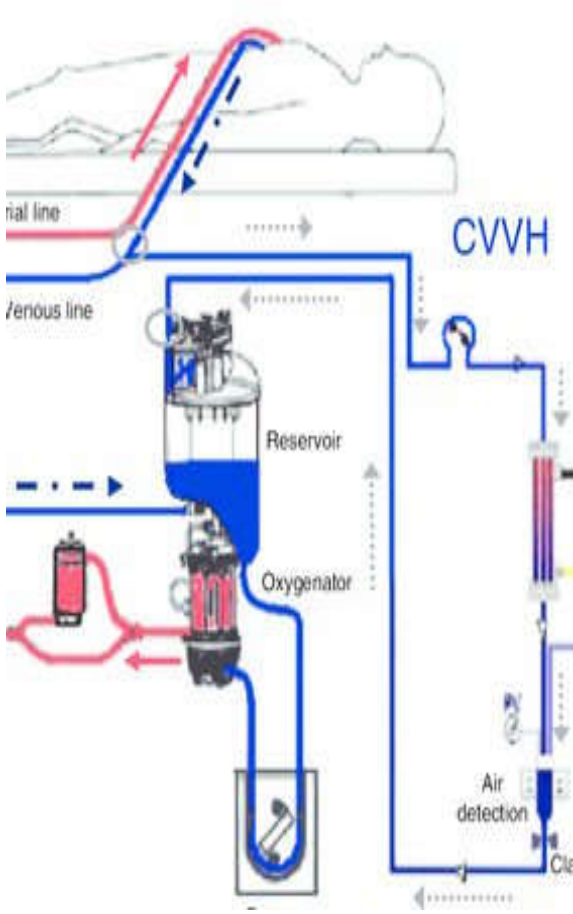
In most cases, the choice of CRRT modality within individual institutions depends on availability and the expertise of the clinician.

Continuous venovenous hemofiltration (CVVH)

Uses hydrostatic pressure to induce the iltration of plasma water across the emofilter membrane.

olutes 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.

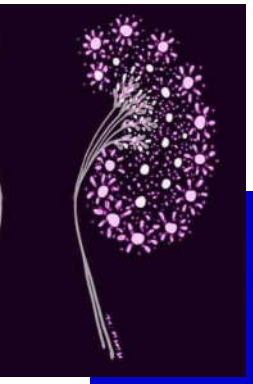
The amount of replacement fluid that is given is determined by the net volume removal that is desired.

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

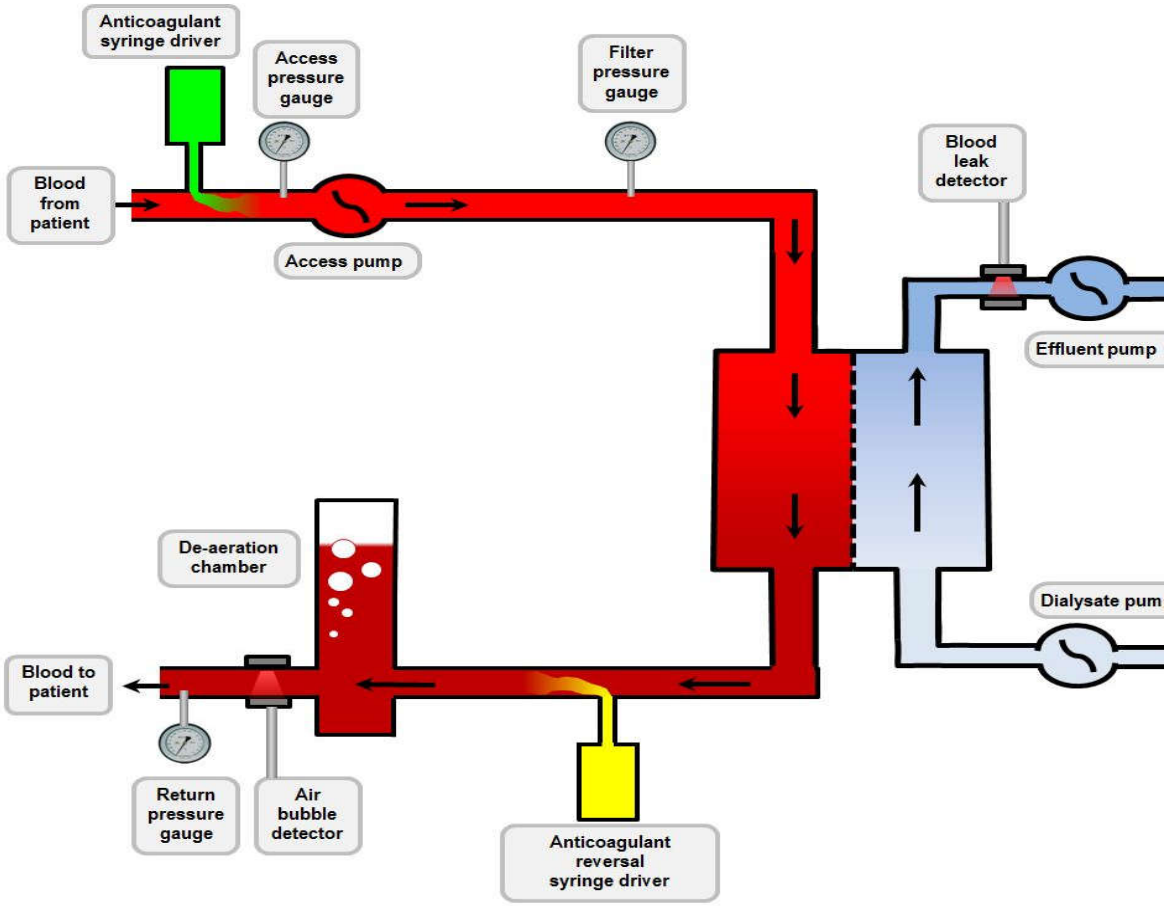
IHD	CVVH
Advantages	
Short duration Cheap Less labor-intensive	Hemodynamic stability Better removal of cytokines
Disadvantages	
Rapid hemodynamic change Technically sophisticated	Continuous anticoagulation Patient immobility Intensive nursing requirement Increased expense

Continuous venovenous hemodialysis (CVVHD)

marily removes solute by
fusion

alysate fluid is used.

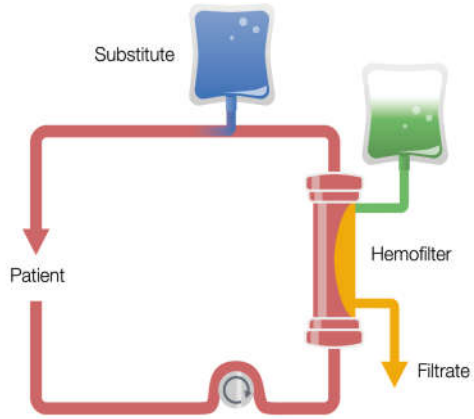
lysate fluid is run
untercurrent to the direction
blood flow at a rate of 1 to 2
our.



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.

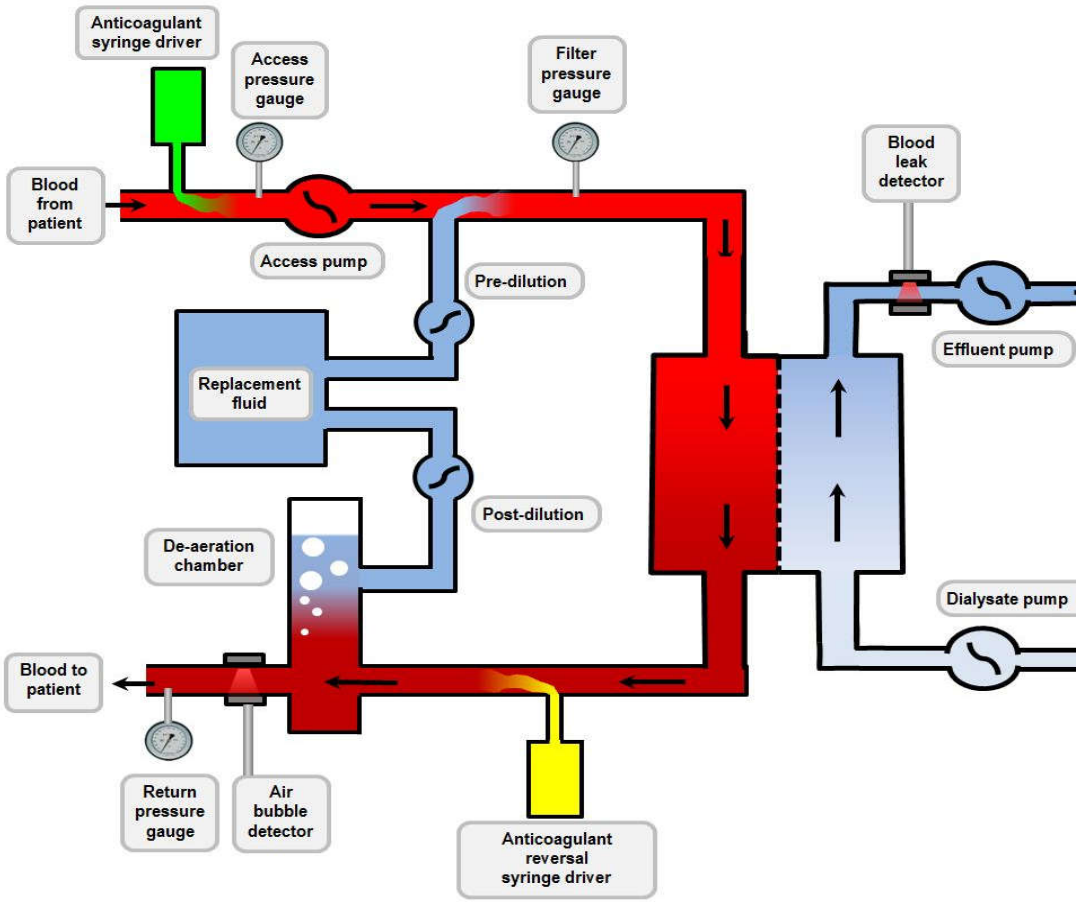


Continuous venovenous hemodiafiltration (CVVHDF)

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.



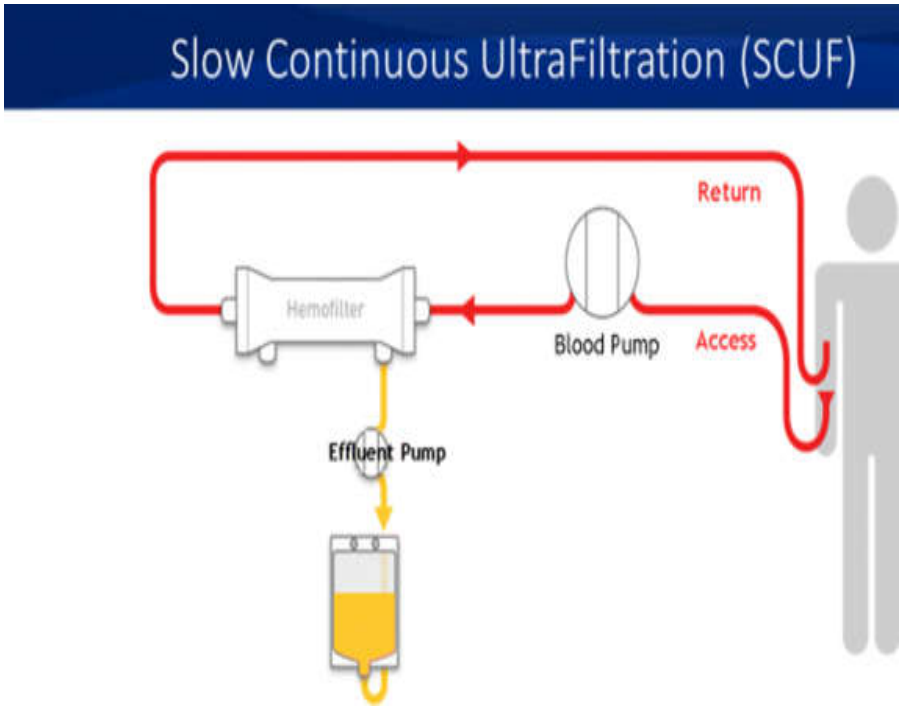
Slow continuous ultrafiltration (SCUF)

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



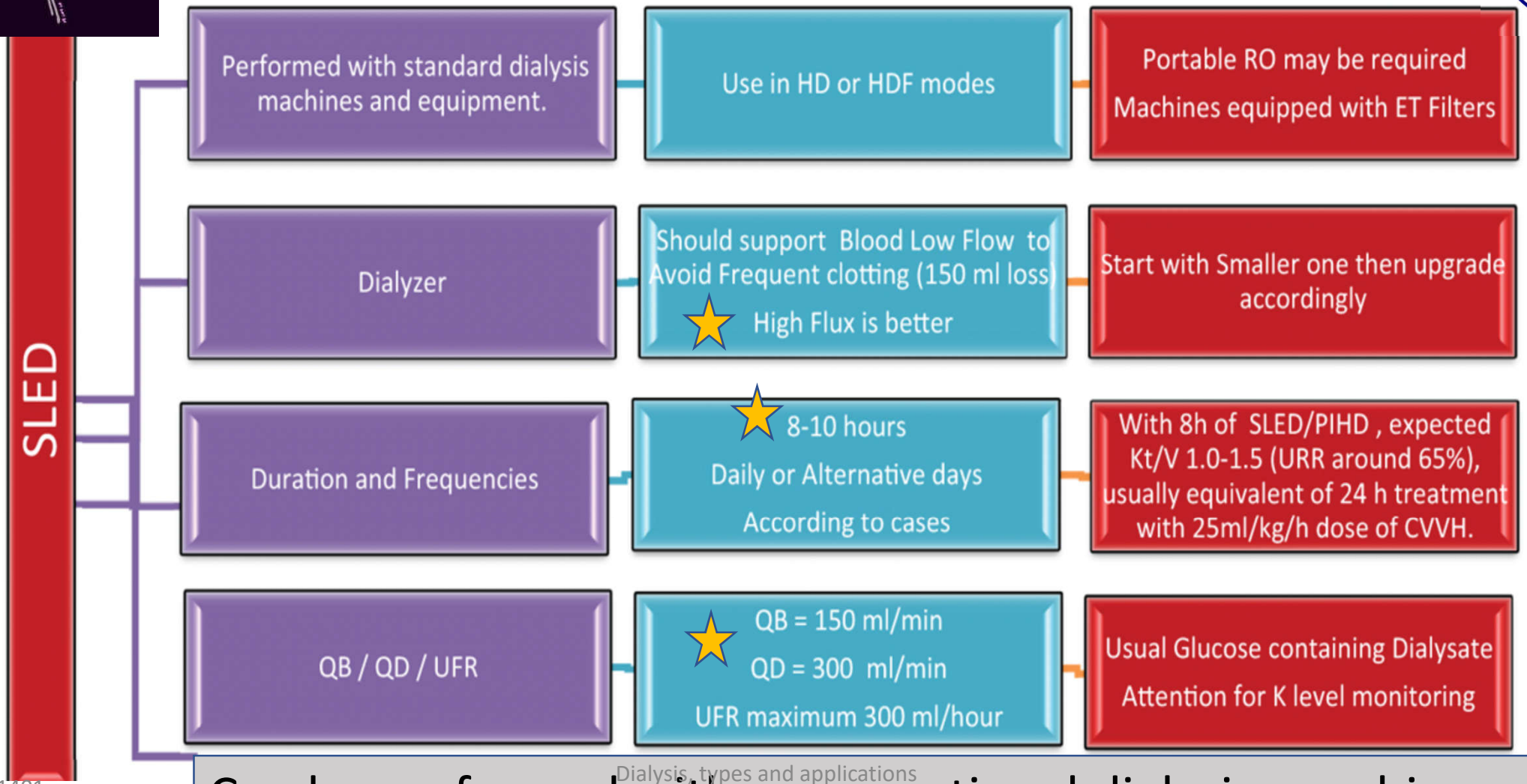
Slow continuous ultrafiltration (SCUF)

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.

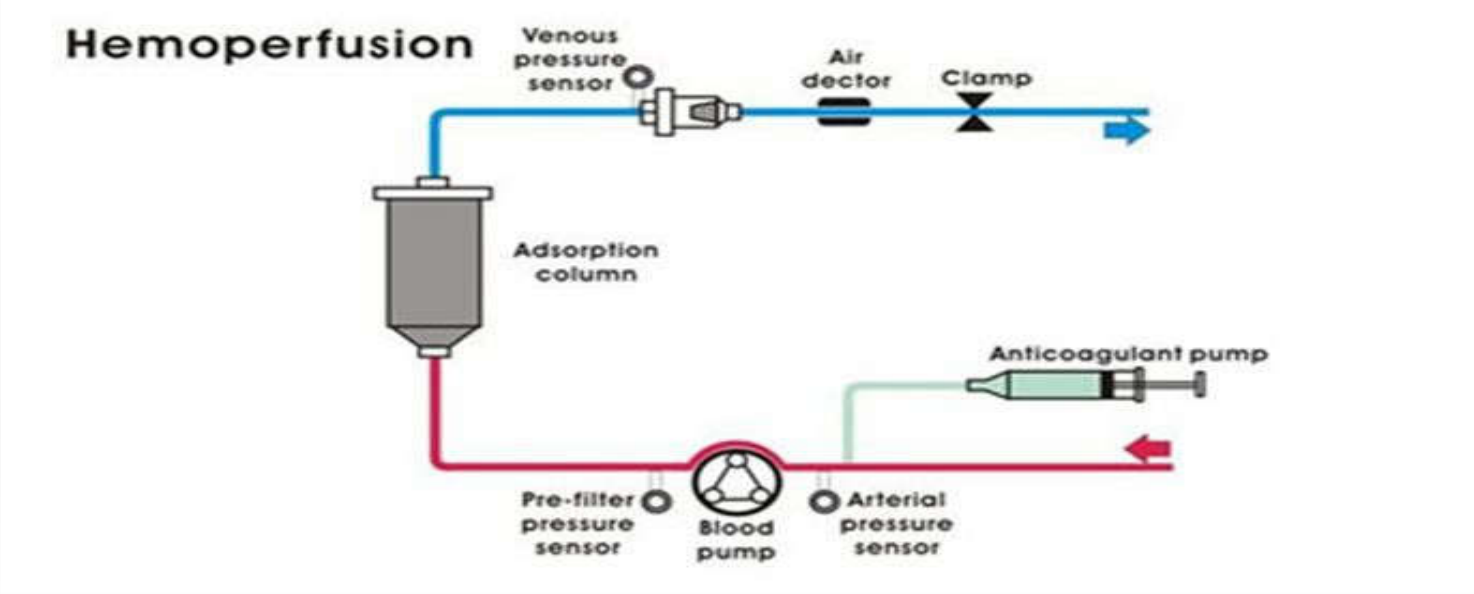
Slow Low Efficiency Dialysis (SLED)



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.

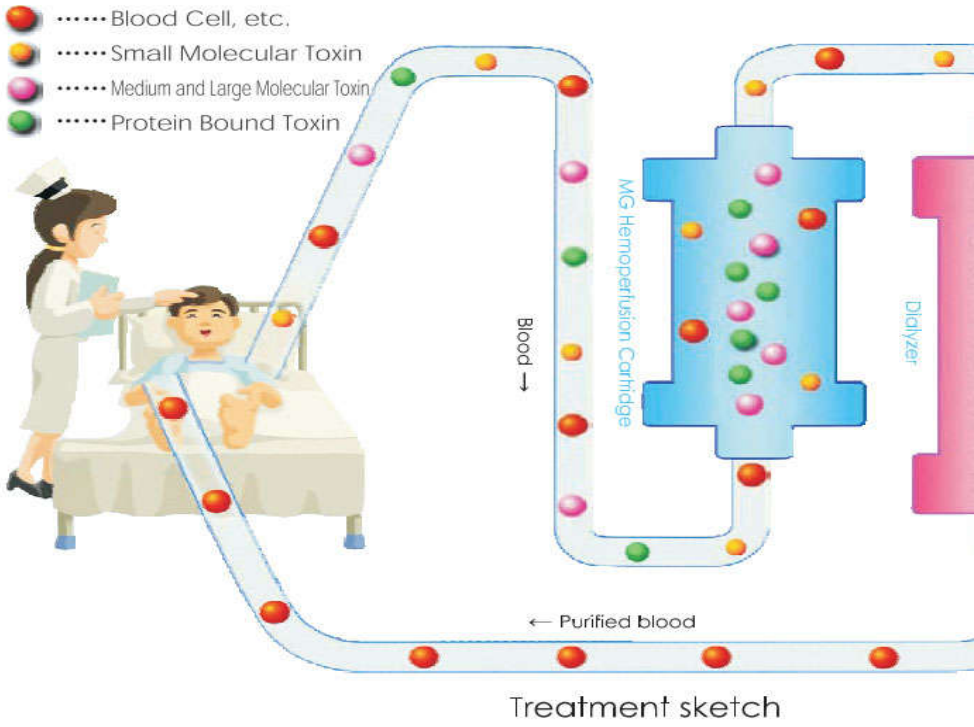
Hemoperfusion

A technique in which the sorbent is placed in direct contact with blood in an extracorporeal circulation

A peristaltic pump via blood lines

irculates blood through

he sorbent cartridge.



Treatment sketch

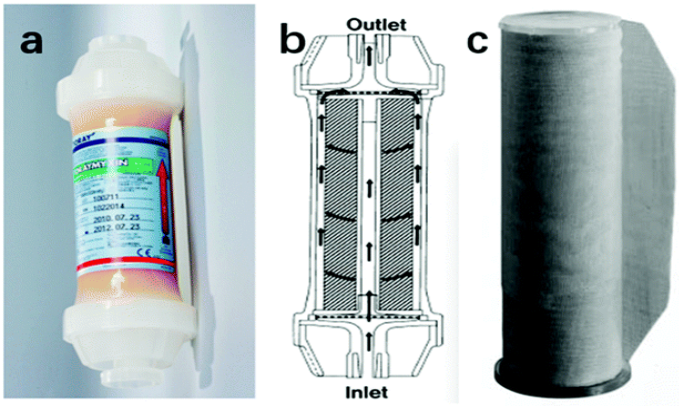
Hemoperfusion

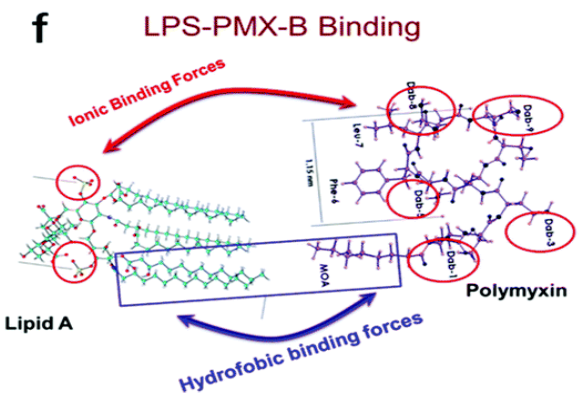
The HP circuit is simpler than one used for hemodialysis but requires adequate anticoagulation and a very biocompatible sorbent because there is a direct contact between blood and sorbent material

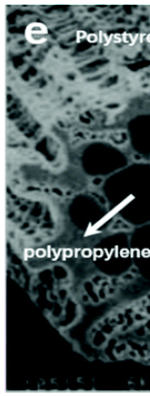
Charcoal has a high adsorbing capacity, especially for relatively hydrophobic, low-molecular-weight solutes that are retained in case of kidney or liver failure.

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.

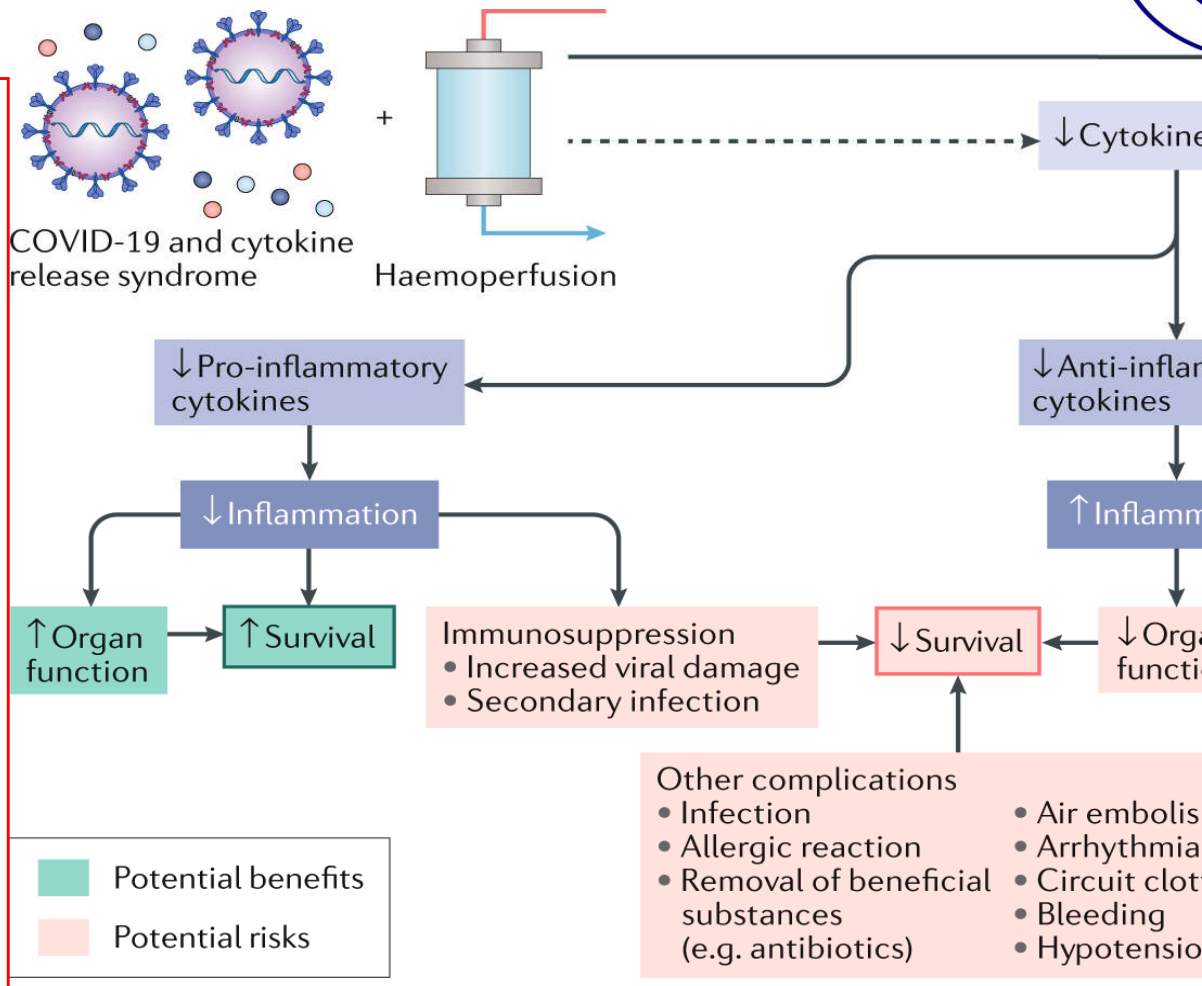






Hemoperfusion

ecause of these recent
dvances, sorbent units are
vailable for direct HP and
ave been demonstrated to
e efficient in removing
oisons, bilirubin,
tokines, or even
ndotoxin.



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