Renal Dialysis

Dialysis was developed as a means for the removal of excess water and metabolic waste products (toxins) from the body that accumulate when there is inadequate renal function. It is commonly used for patients with end-stage renal disease (ESRD).

❖ Renal replacement therapy

- Renal replacement therapy (RRT) replaces non-endocrine kidney function in patients with renal failure and is occasionally used for some forms of poisoning.
- All modalities exchange solute and remove fluid from the blood, using dialysis and filtration across permeable membranes.
- RRT **does not** correct the endocrine abnormalities (decreased erythropoietin and 1, 25-dihydroxyvitamin D_3 production) of renal failure.
- During dialysis, serum solute (e.g., Na, Cl, K, HCO_3, Ca, Mg, phosphate, urea, creatinine, and uric acid) diffuses passively between fluid compartments down a concentration gradient (diffusive transport).
- During filtration, serum water passes between compartments down a hydrostatic pressure gradient, dragging solute with it (convective transport).
- Renal replacement therapy is indicated in a patient with AKI when kidney function is so poor that life is at risk, also inPatients who progress to ESRD. However,it is desirable to introduce renal replacement therapy early in AKI, as complications and mortality are reduced if the serum urea level is kept below 35 mmol/L.

- ***Generally, replacement therapy is urgently indicated in AKI to***:

1 .Remove uraemic toxins when severe symptoms are apparent, for example, impaired consciousness, seizures, pericarditis, and rapidly developing peripheral neuropathy

2 .Remove fluid resistant to diuretics, for example, pulmonary edema

3 .Correct electrolyte and acid–base imbalances, for example, hyperkalaemia >6.5 mmol/L or 5.5–6.5 where there are ECG changes, increasing acidosis (pH < 7.1 or serum bicarbonate <10 mmol/L) despite bicarbonate therapy, or where bicarbonate is not tolerated because of fluid overload.

❖ **Forms of renal replacement therapy**

The common types of renal replacement therapy used in clinical practice are:

- **haemodialysis**
- **haemofiltration**
- **haemodiafiltration**
- **Peritoneal dialysis**

Although the basic principles of these replacement therapiesare similar, clearance rates, that is, the extent of soluteremoval, vary.

In all types of renal replacement therapy, blood is presented to adialysis solution across some form of semi-permeable membrane that allows free movement of low molecular weight compounds.

❖ The processes by which movement of substances occur are:

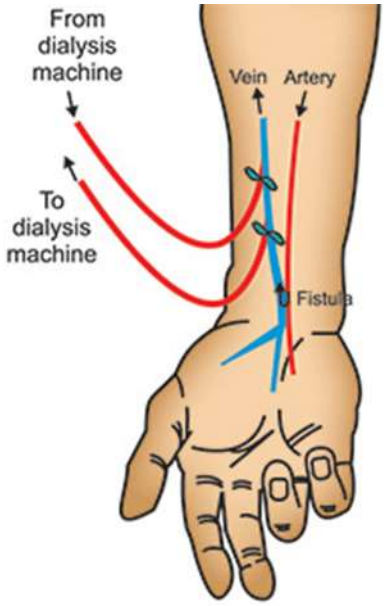
•Diffusion. Diffusion depends upon concentration differences between blood and dialysate and molecule size. Water and low molecular weight solutes (up to amolecular weight of about 5000) move through pores in the semi-permeable membrane to establish equilibrium.

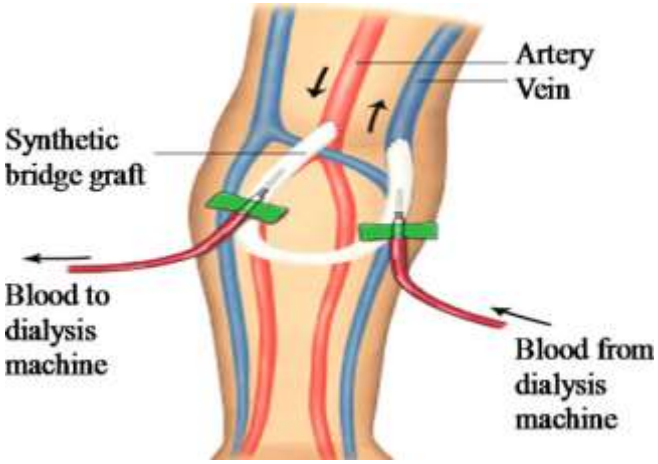
Smaller molecules can be cleared from blood more effectively as they move more easily through pores in the membrane.

•Ultrafiltration. A pressure gradient (either +ve or −ve)across a semi-permeable membrane will produce a net directional movement of fluid from relative high to low pressure regions. The quantity of fluid dialysed is the ultrafiltration volume.

•**Convection**. Any molecule carried by ultra-filtrate may move passively with the flow by convection. Larger molecules are cleared more effectively by convection.

Vascular Access: Permanent vascular access provides easy access to high blood flow for HD.Different types of access exist: arteriovenous (AV) fistula, AV graft.





Dialysate(The dialysis solution) is essentially a mixture of electrolytes in water with a composition approximating to extracellular fluid into which solutes diffuse .Electrolyte composition of HD and PD dialysate solutions are shown in Table .

TABLE 32.1 **Electrolyte Composition of Hemodialysis and CAPD Dialysate Solutions**

Solute	Hemodialysis (mEq/L)	CAPD (mEq/L)
Sodium	135–145	132
Potassium	0–4	0
Calcium	2.5–3.5	3.5
Magnesium	0.5–1.0	1.5
Chloride	100–124	102
Bicarbonate	30–38	
Lactate		35
pH	7.1–7.3	5.5

CAPD, continuous ambulatory peritoneal dialysis.

a. Hemodialysis

- Hemodialysis is the preferred dialysis method for patients with a reduced peritoneal membrane, hyper catabolism, or acute hyperkalemia.

- Permanent vascular access is placed in a vein (the jugular, femoral or sub-clavian).
- The patient's anticoagulated blood and a dialysate solution flow in opposite directions through a dialyzer, providing constant perfusion of fresh dialysate thereby maintaining a large concentration gradient across the dialysis membrane throughout the dialysis process. Solutes (metabolic waste products, electrolytes) are removed from the blood by diffusing across concentration gradients into the dialysate.
- Most patients are anticoagulated with **IV heparin** during dialysis to prevent blood from clotting in the extracorporeal circuit. Heparin ***should be discontinued 1 hour*** before the end of dialysis to prevent excessive bleeding.
- The procedure takes only **3 to 8 hrs**. Most patients need **three** treatments a week.

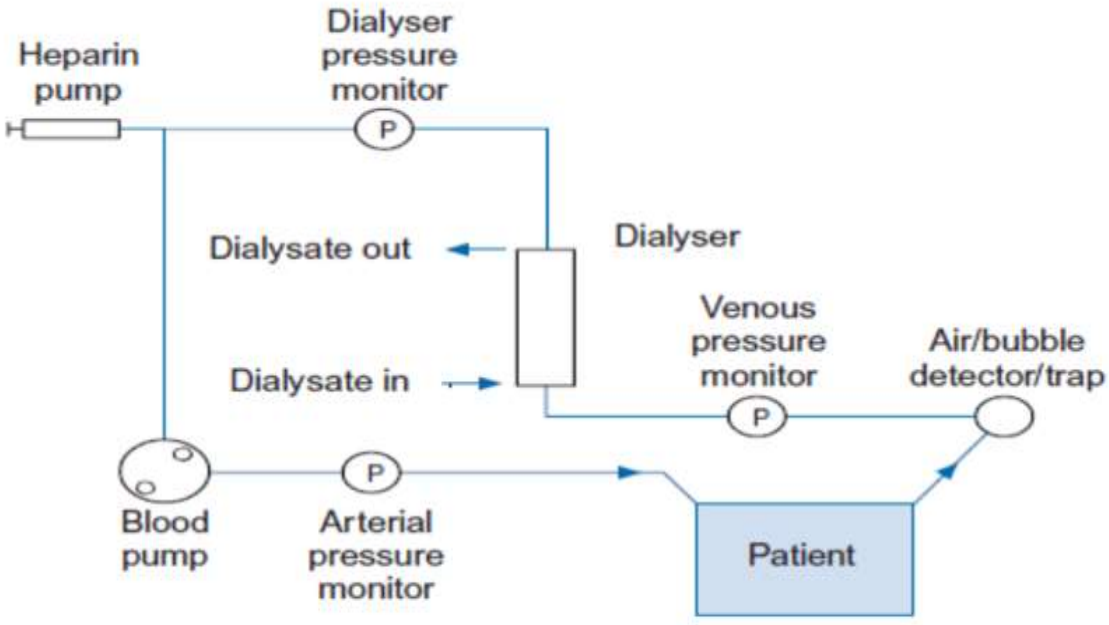
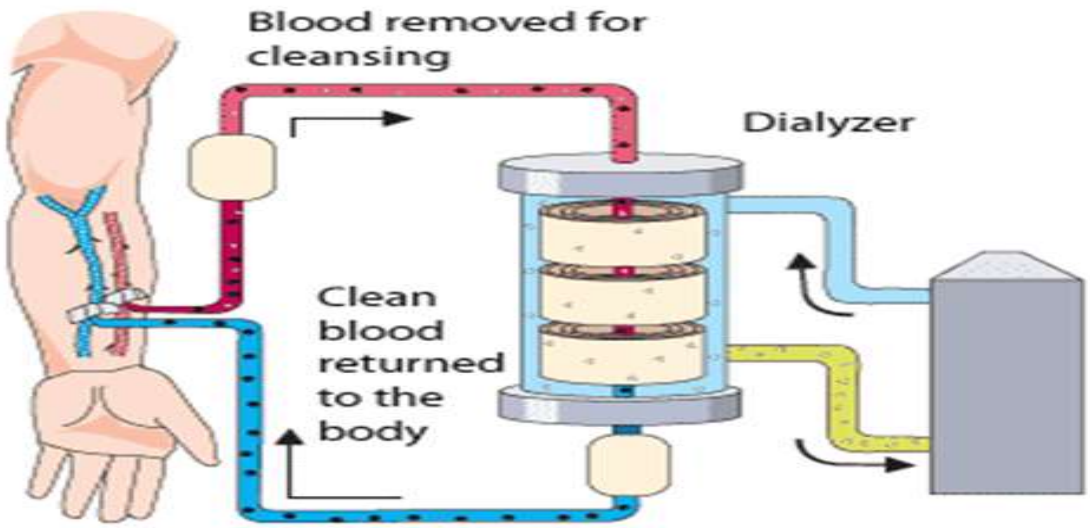


Fig. 17.5 A typical dialysis circuit representing emergency dialysis via a dialysis catheter.



- This technique involves shunting of the patient's blood through a dialysis membrane containing unit for diffusion, osmosis, and ultrafiltration. The blood is then returned to the patient's circulation.
- Vascular access may be obtained via an arteriovenous fistula or an external shunt.
- The capital cost of haemodialysis is considerable, requires specially trained staff, and is seldom undertaken outside a renal unit. It does, however, treat renal failure rapidly and is, therefore, essential in hypercatabolic renal failure where urea is produced faster.

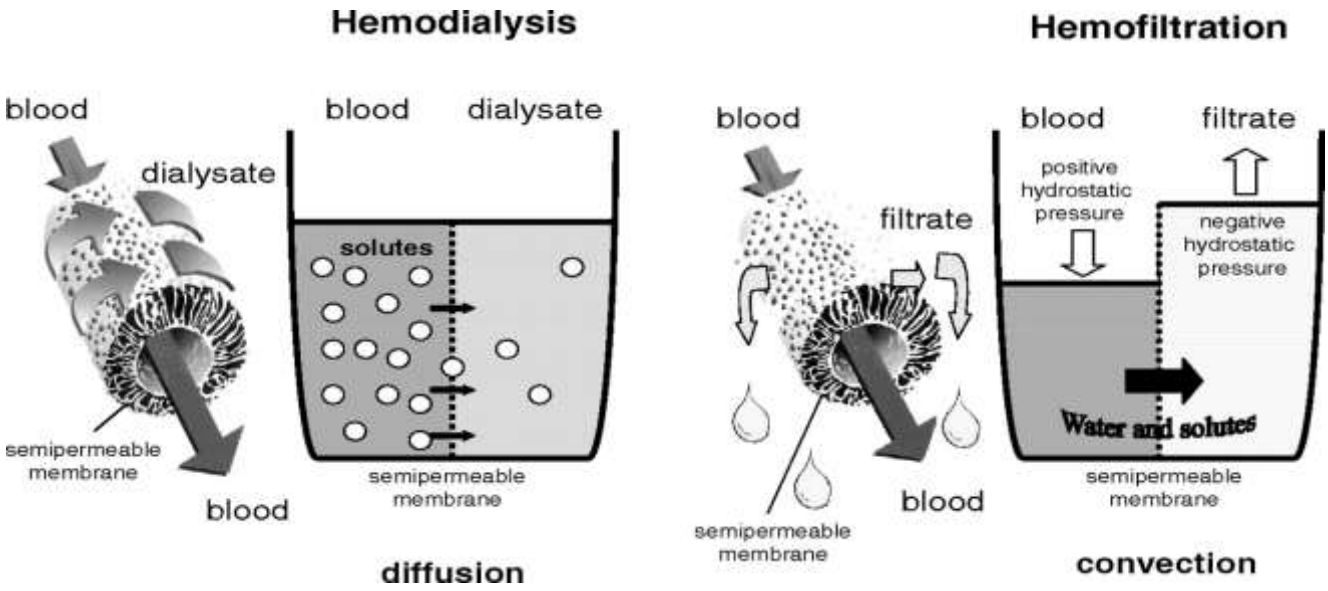
❖ Complications of haemodialysis

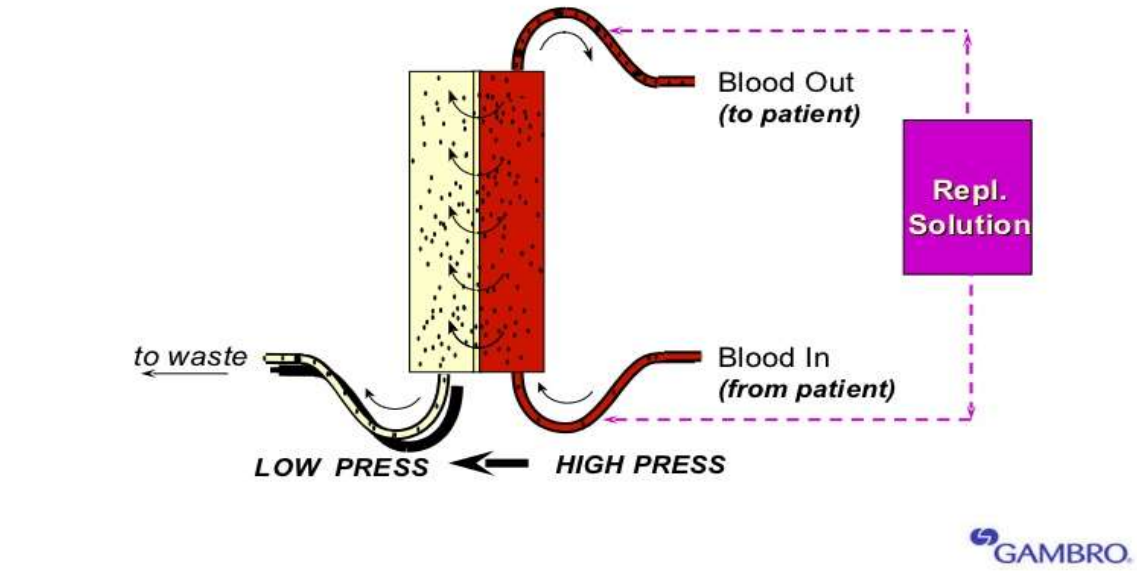
- ✓ **Intradialytic hypotension** caused by excessive fluid removal or excessive heating of the dialysate. Treatment options include midodrine (10–20 mg 30 minutes before dialysis), sertraline (50–100 mg daily), and IV L-carnitine (20 mg/kg at dialysis).
- ✓ **Muscle cramps:** Treatment can include reduced ultrafiltration and infusion of hypertonic saline or glucose to improve circulation, exercise/stretching of affected limb, or vitamin E 400 IU at bedtime with vitamin C 250 mg daily for prevention.
- ✓ **Hypersensitivity**, most commonly to the dialyzer membrane.
- ✓ **Dialysis disequilibrium** caused by shifting of free water into the brain, causing cerebral edema. Treatment is aimed at prevention by initiating dialysis gradually. Direct treatment involves IV hypertonic saline or mannitol.
- ✓ **Thrombosis** (usually a consequence of venous stenosis): alteplase or retavase are effective for thrombomechanical lysis of the vascular access site.

- ✓ **Access infection** (typically caused by *S. aureus* or *S. epidermidis*): prophylactic antibiotics offer no value. If infection is suspected, prompt treatment is needed. Vancomycin 1 g repeated as needed depending on type of dialysis, or cefazolin 20 mg/kg three times weekly with gentamicin 2 mg/kg with appropriate serum concentration monitoring.
- ✓ **Aluminum toxicity** (dementia, bone disease, anemia): deferoxamine can be used to chelate serum aluminum.
- ✓ **Amyloidosis** caused by deposition of *b*2-microglobulin in joints and soft tissue.
- ✓ **Malnutrition** caused by inadequate dietary intake, loss of amino acids through dialysis, and the catabolic stated cause by ESRD.

❖ Haemofiltration

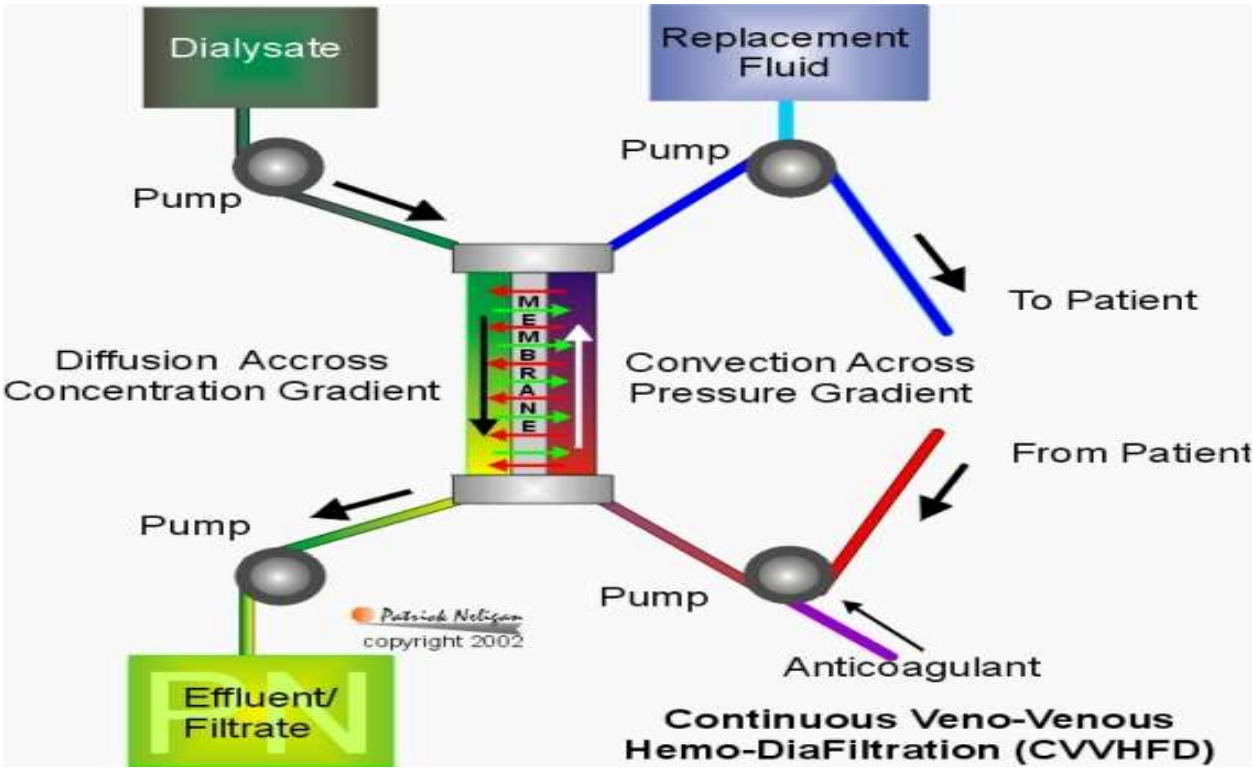
- ✓ Haemofiltration is an alternative technique to dialysis where simplicity of use, fine fluid balance control and low cost have ensured its widespread use in the treatment of AKI.A similar arrangement to haemodialysis is employed but dialysis fluid is not used.
- ✓ The hydrostatic pressure of the blood drives a filtrate, similar to interstitial fluid, across a high permeability dialyzer (passes substances of molecular weight up to 30,000) by ultrafiltration. Solute clearance occurs by convection.



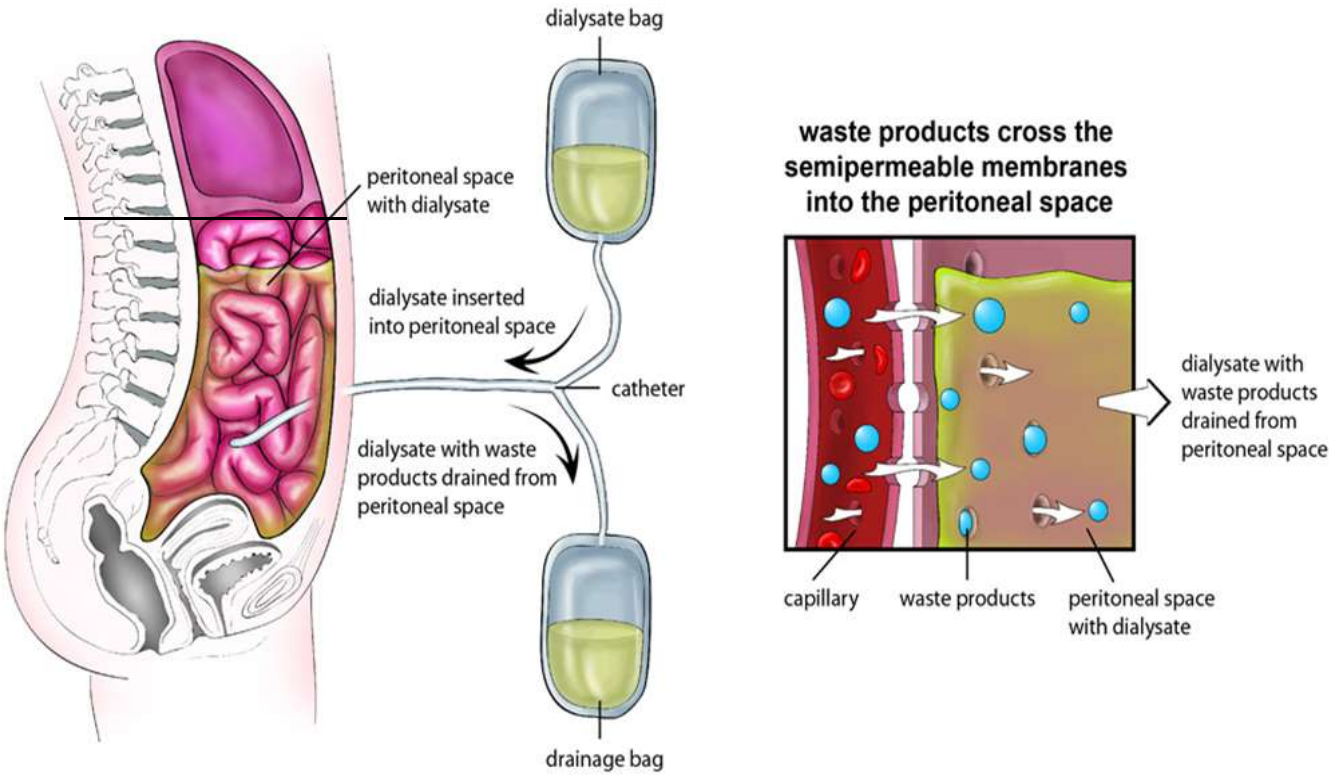


❖ Haemodiafiltration

Haemodiafiltration is a technique that combines the ability to clear small molecules, as in haemodialysis, with the large molecule clearance of haemofiltration. It is, however, more expensive than traditional haemodialysis, but does offer potential benefits. Whilst some studies suggest that haemodialfiltration may provide a clinical benefit comparedto haemofiltration or haemodialysis, this is controversial(Rabindranath et al., 2006). However, enhanced combinedcontrol of fluid and solute removal provided by this techniqueis likely to be increasingly used over the next decade.



❖Peritoneal dialysis



Peritoneal dialysisis the preferred dialysis method for patients with bleeding disorders and cardiovascular disease.

- The peritoneum is used as a semipermeable membrane. A plastic catheter inserted into the peritoneum provides access for the dialysate, which draws fluids, wastes, and electrolytes across the peritoneal membrane by osmosis and diffusion.
- Acute peritoneal dialysis is rarely used now for AKI except in circumstances where haemodialysis is unavailable.
- Acute peritoneal dialysis is relatively cheap and simple, does not require specially trained staff or the facilities of a renal unit.

❖ Advantages of peritoneal dialysis

include a lack of serious complications, retention of normal fluid and electrolyte balance, simplicity, reduced cost, patient independence, and a reduced need (or no need) for heparin administration.

❖ Complications of peritoneal dialysis

Include hyperglycemia, constipation, and inflammation or infection at the catheter site. It does have the disadvantages of being uncomfortable and tiring for the patient. It is associated with a high incidence of

peritonitis and permits protein loss, as albumin crosses the peritoneal membrane.

Common Dialysis Medicines

1- Phosphate Binders

Phosphate Binders should be taken within 30 minutes of a meal, so it can bind with phosphorus foods and leave the body through the stool. Dialysis does a poor job of phosphorus removal so taking phosphate binders and Limit foods containing phosphorus are the only ways to get rid of excess phosphorus from the body.

2-Antihypertensive

Most agents can be safely prescribed in patients with ESRD and dialysis

- Post dialysis dosing or extra doses after HD may be necessary for certain antihypertensive agents.
- Angiotensin converting enzyme inhibitors (ACE-I): all are dialyzable except fosinopril
- Angiotensin receptor blockers (ARB): none are dialyzed
- B-blockers: atenolol and metoprolol are dialyzable
- Calcium channel blocker: amlodipine is not dialyzable

3-Anticoagulants

Low-MW heparin will accumulate in patients with ESRD so prefer to avoid if used, follow anti–factor Xa levels and reduce the dosing interval

4-Vitamins and Supplements

Dialysis removes B vitamins and folic acid.

5- Epoetin: dialysis decrease epoetin level so must be given as an injection or during dialysis treatment.

6-L-carnitine

L-carnitine, an amino acid-derived nutrient crucial to cellular energy management, may play a vital role in kidney disease prevention and management.

Carnitine deficiency is itself a known causative factor in the development of kidney disease. Conversely, patients with kidney disease frequently develop carnitine deficiency, especially those on dialysis.

Carnitine therapy is known to lead to improvements in many kidney disease-related complications including cardiovascular disease, anemia, decreased exercise tolerance, weakness, and fatigue.

As noted earlier, CKD sufferers are at very high risk for developing cardiovascular complications, including heart attacks and heart failure. This is thought to be related in part to the massive oxidative stress induced by kidney disease and in part to inadequate energy management in cardiac tissues induced by carnitine deficiency.

Based on patient reported outcomes, supplementation with L-carnitine could improve general health, vitality, and physical function in people on dialysis.

L-carnitine given intravenously to dialysis patients could

A- Reduce fatigue and preserve exercise capacity,

B-improve red blood cell count in dialysis patients whose anemia doesn't respond to therapy with the hormone erythropoietin.

C-help to suppress levels of the inflammatory marker C-reactive protein, potentially reducing cardiovascular risk in dialysis patient's

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