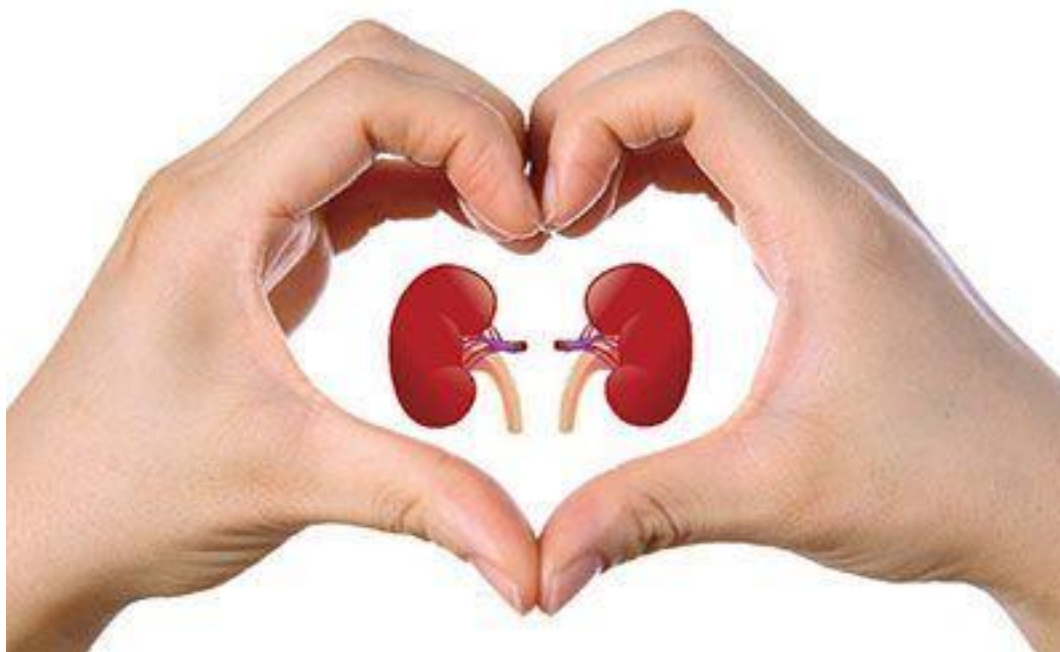


Renal Replacement Therapy



Dr Mirhosseini

Assistant Professor of Nephrology

Referral and Education for Patients with Progressive CKD

- ▶ Refer patients early, when $\text{eGFR} < 30 \text{ ml/min/1.73 m}^2$
- ▶ Education about types of renal replacement therapy:
 - Hemodialysis (vascular access +++)
 - Peritoneal Dialysis (QOL advantage +++)
 - Kidney Transplantation
 - ▢ Refer when $\text{eGFR} < 20 \text{ ml/min/1.73 m}^2$
 - ▢ Living kidney transplant (family, friends)
 - ▢ Build time on list before dialysis initiation
 - ▢ Even transplant before dialysis initiation (pre-emptive)
- ▶ No PICC lines for patients with $\text{eGFR} < 45 \text{ mL/min/1.73m}^2$

Advantages of Timely Referral in Patients with Progressive CKD

- ▶ Improves patient preparation for RRT
- ▶ Greater use of permanent vascular access
- ▶ Avoidance of emergent hemodialysis initiation
- ▶ Greater utilization of transplantation and self-care dialysis (i.e., peritoneal dialysis or home hemodialysis)
- ▶ Management of medications which may help to delay the need for RRT
- ▶ Gives the nephrologist adequate time to counsel patients through this challenging transition in their lives

- The overall incidence of ESRD is 260 case per million population per year.
- The incident population of patients with ESRD is increasing at approximately 6% each year.
- Leading cause of ESRD DM 45% , HTN 28% , GN PCKD , Obstructive uropathy.
- Mortality rate of patients on dialysis 18% per year.
- Death are due mainly to cardiovascular disease 50% and infection 15%.

Indications for Renal Replacement Therapy

Clip slide

- ▶ Hyperkalemia
- ▶ Metabolic acidosis
- ▶ Fluid overload (recurrent CHF admissions)
- ▶ Uremic pericarditis (rub)
- ▶ Other non specific uremic symptoms:
anorexia and nausea, impaired nutritional status, increased sleepiness, and decreased energy level, attentiveness, and cognitive tasking, ...

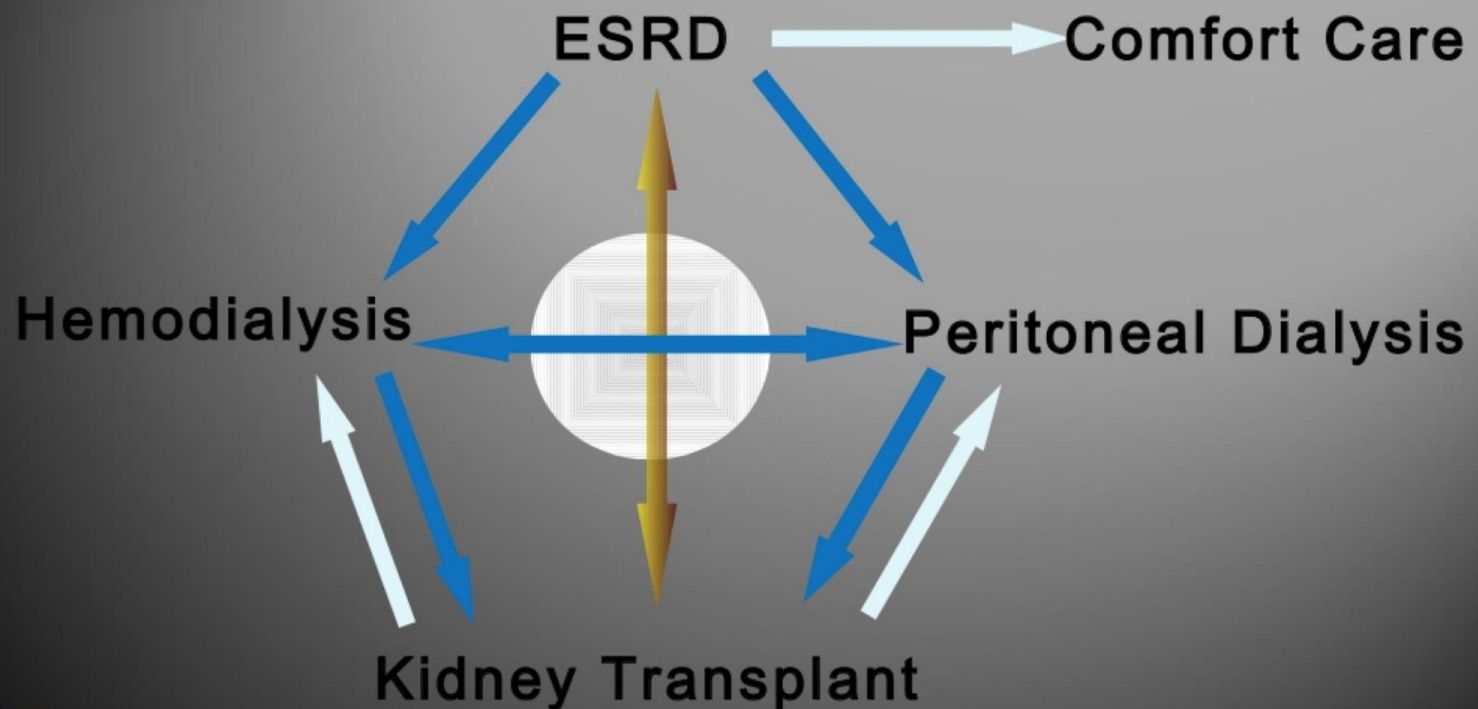
Is Timing of Dialysis Initiation Important in ESRD Patients? (Controversial)

Implications

- Total of 75.9% of the patients in the late-start group started dialysis when eGFR was $> 7.0 \text{ mL/min/1.73m}^2$, owing to the development of symptoms!
- In this study, planned early initiation of dialysis in patients with stage V CKD was not associated with an improvement in survival or clinical outcomes (QOL)
- ➔ OK to delay initiation of dialysis ($\text{eGFR} < 7\text{-}10 \text{ mL/min/1.73m}^2$)
- ➔ Dialysis initiation should be based upon clinical factors (symptoms) rather than eGFR alone

Treatment Options for Renal Replacement Therapy

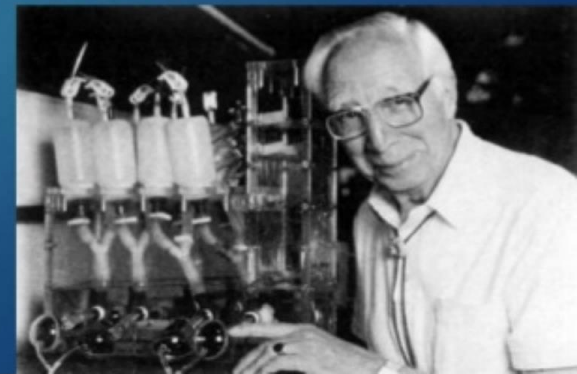
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- ▶ 1854 the first time the term dialysis was used by Thomas Graham
- ▶ 1889 BW Richardson First referred the use of collodion membrane in the dialysis of blood .This help the living animals were dialysed in experimental conditions.

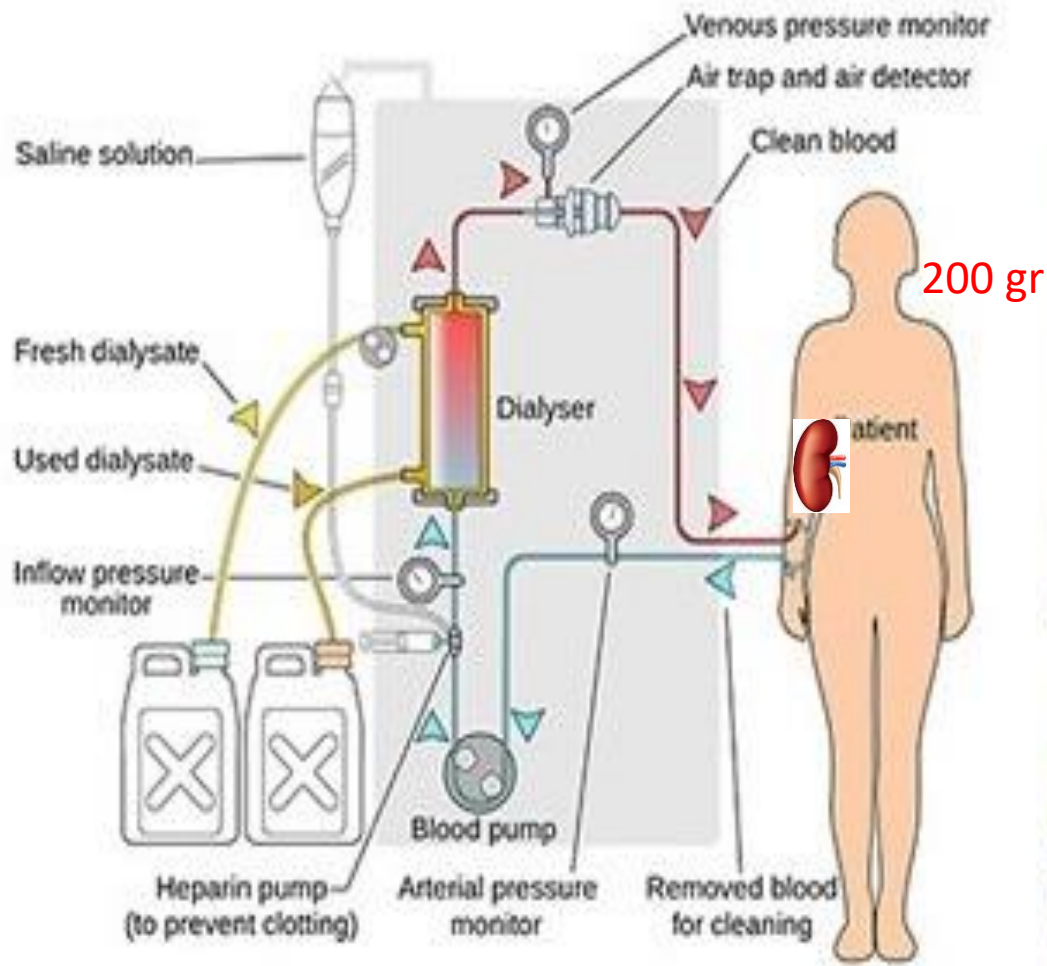


- ▶ In 1945 William Kolff first clinical experience was gained on a 29 year old women with chronic nephritis. The blood urea was kept stable for 26 days but after 12 sessions of dialysis her blood urea began to increase and she subsequently died.
- ▶ After the world war Kolff technique was wildly used.



- ▶ Followed by this invention hemodialysis started.
- ▶ In late 1970s and early 1980s the continuous ambulatory peritoneal dialysis as the first choice of home treatment.
- ▶ The innovations in the field of dialysis is reaching up to the satellite dialysing unit nowadays. And the patient surveillance rate also increase.

Hemodialysis (HD)



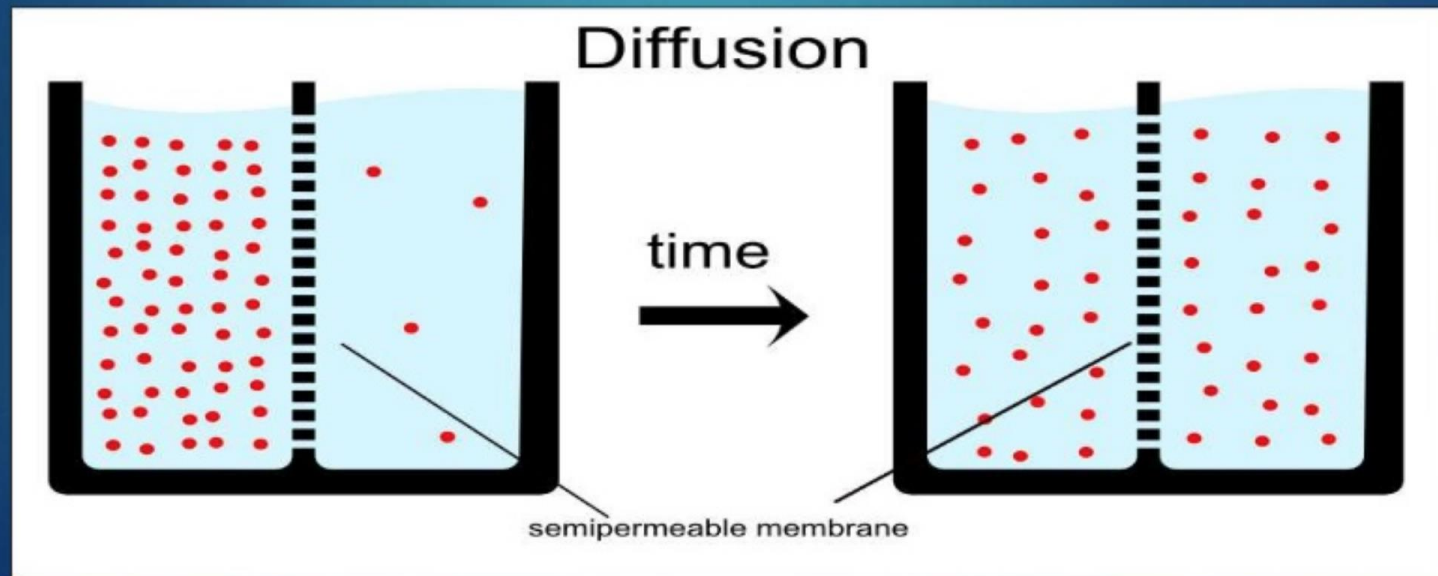


PRINCIPLES OF HEMODIALYSIS:

- **Diffusion** is the movement of **particles** from an area of greater concentration to one of lesser concentration
- **Osmosis** is the movement of **fluids** across a semipermeable membrane from an area of lesser concentration of particles to an area of greater concentration of particles
- **Ultrafiltration** is the movement of **fluid** across a semipermeable membrane as a result of an **artificially created pressure gradient**

Principles of Dialysis

- **Diffusion:** Diffusion is the movement of solutes from an area of greater concentration to an area of lower concentration.

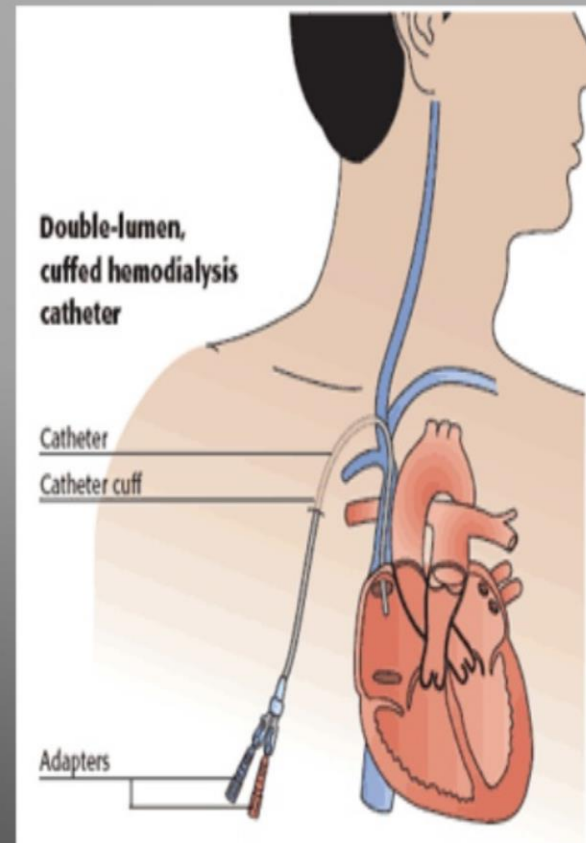
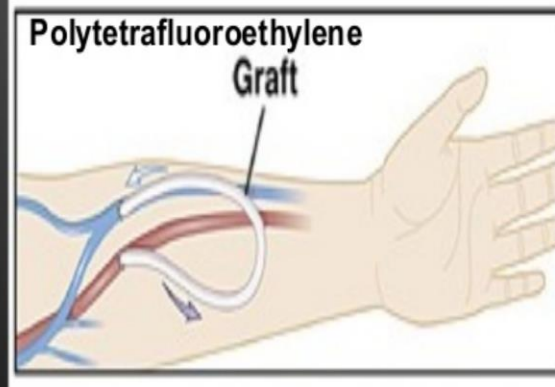
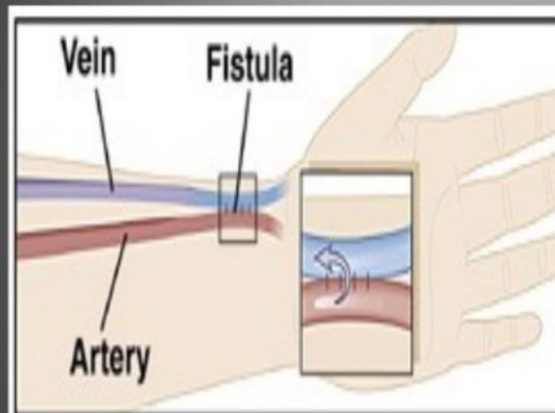


- **Ultra filtration:** Ultra filtration that is solution move when there is an osmotic gradient or pressure gradient across the membrane.



Hemodialysis Vascular Access

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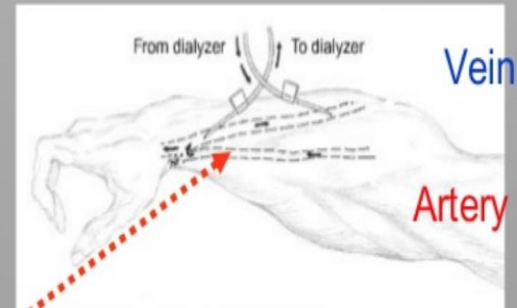
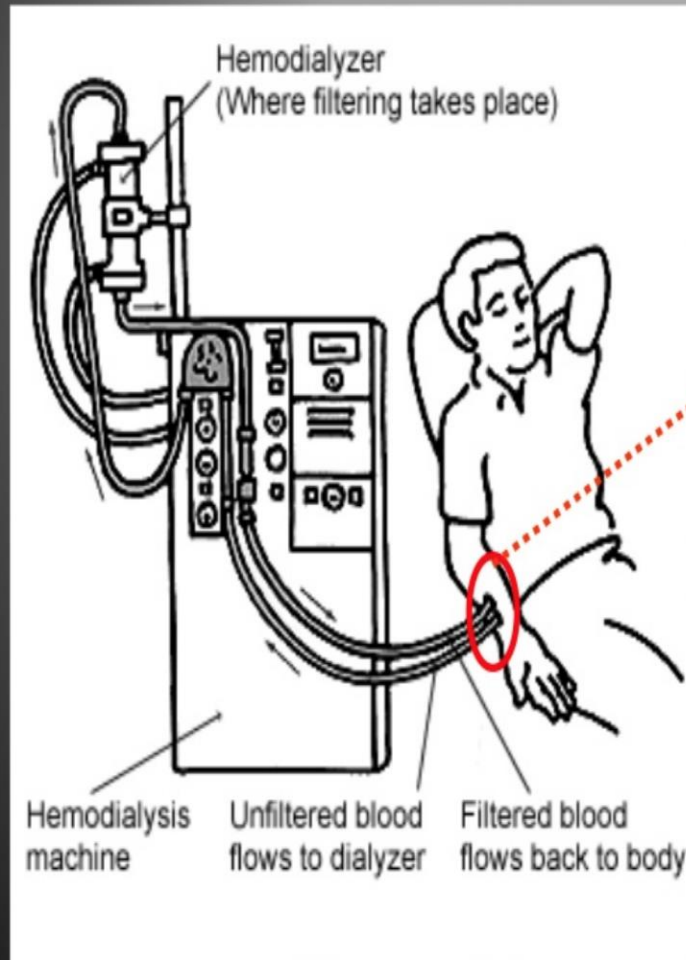


Dialysis Access

- ▶ Catheter (IJ most common)
 - Tunnelled under skin to reduce communication from skin flora with blood
 - Advantages
 - ▢ Ready for use immediately
 - Disadvantages
 - ▢ High infectious risk
 - ▢ High thrombosis risk
 - ▢ A/W increased mortality
 - ▢ Can be a sign of poor pre-dialysis care or extensive vascular disease



Principle of Hemodialysis



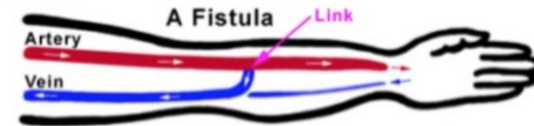
Arteriovenous (AV) Fistula



Dialysis Access

▶ AV Fistula

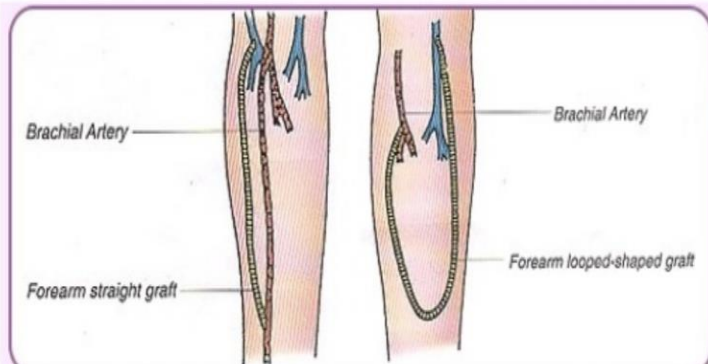
- Vein cross-cut, attached end-to-side to artery
- High-pressure flow dilates and thickens vein
- Best alternative:
 - ▢ Lowest infectious risk
 - ▢ Longest lasting with least thromboses
- Drawbacks
 - ▢ Takes 2-4 months to mature
 - ▢ Only about 50% ever mature
- Goal for all dialysis patients



Dialysis Access

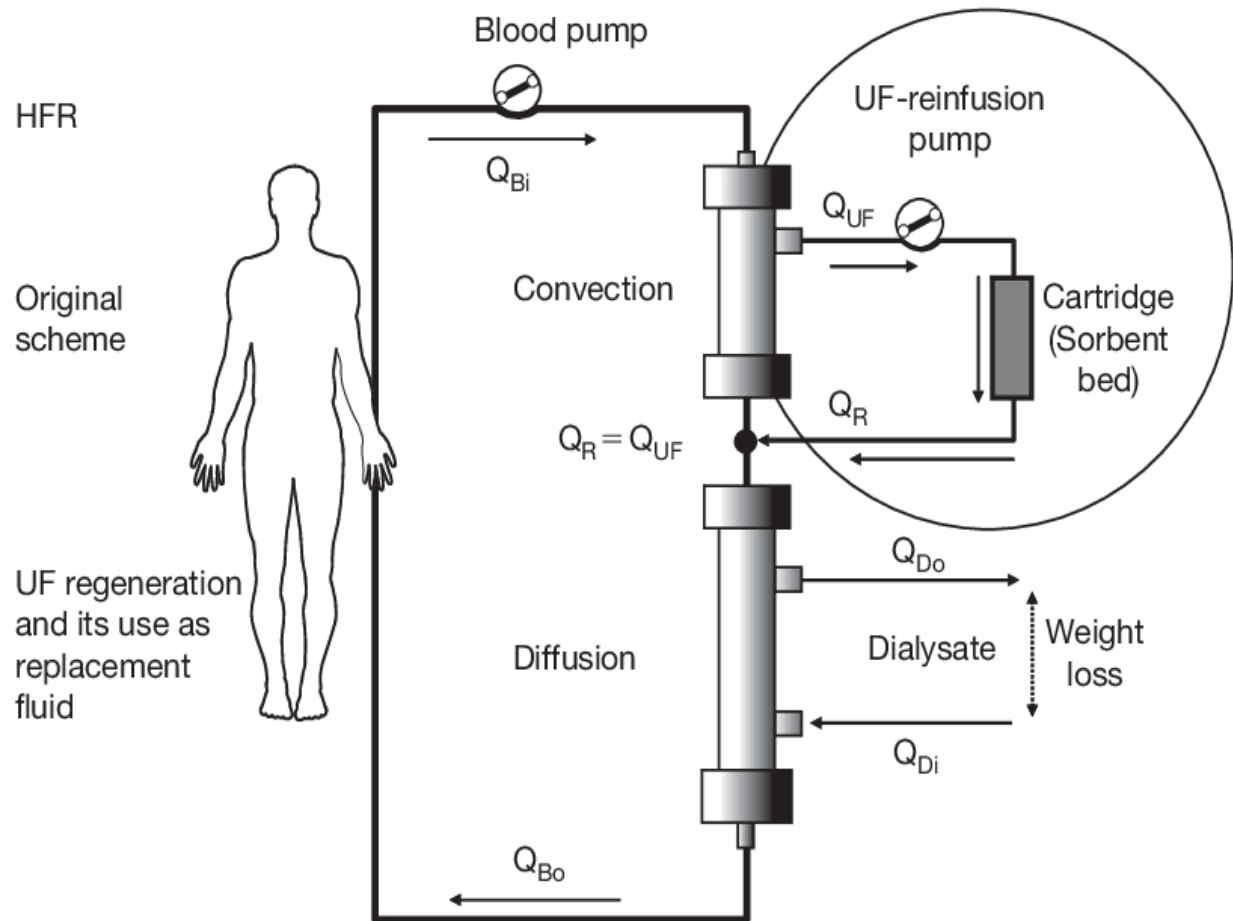
▶ AV Graft

- Tube made of biocompatible material (gortex) attached end-to-side to artery and vein
- Often required in patients with vascular disease, occluded distal veins
- Advantages
 - ▢ Ready to use when swelling resolves (~2 weeks)
 - ▢ Able to use in most patients
- Disadvantages
 - ▢ High stenosis/thrombosis
 - ▢ Moderate infectious risk



Vascular Access Guidelines

- ▶ **Arm veins suitable for placement of vascular access should be preserved, regardless of arm dominance.** Arm veins, particularly the cephalic veins of the non-dominant arm should not be used.
 - **Avoid PICC lines**
- ▶ **Dorsum of the hand** could be used for IV.
- ▶ A Medic Alert bracelet should be worn to inform hospital staff to avoid IV cannulation of essential veins.
- ▶ **Subclavian vein catheterization should be avoided** for temporary access in all patients with CKD (→ stenosis → preclude use of ipsilateral arm for vascular access)



- Q_{Bi} Blood flow at the dialyzer inlet
- Q_{Bo} Blood flow at the dialyzer outlet
- Q_{Di} Dialysate flow at the dialyzer inlet
- Q_{Do} Dialysate flow at the dialyzer outlet
- UF Ultrafiltrate
- Q_{UF} Ultrafiltrate flow
- Q_R Reinfusate flow





Semi-permeable membrane

- A semi-permeable membrane is a type of thin, flexible filter a barrier that allows only particles smaller than a certain size to pass through it.



- The membrane is housed in a plastic case, which holds the dialyzer together and forms pathways for blood and dialysate to flow in and out.
- The semipermeable membrane acts like the vessel wall of a human nephron, because it is selective.



Dialysate Solution



- A solution is a mixture of a solvent and a solute. The solvent is a fluid. The solute is any substance that can be dissolved into the solvent.
- Dialysate is the solution that is used during dialysis. Water is the solvent. The solutes are electrolytes (e.g., potassium, calcium, sodium, magnesium, and chloride ions) and glucose (Sugar). Electrolyte levels in dialysate closely match the levels in human blood.



Dialysander 600 (5 L)

Dilution 1:34		621-A	621-N	622-A	600-B
Na	mEq/L	104	104	103	35
K	mEq/L	1	2	1,5	-
Ca	mEq/L	3	3,5	2,5	-
Mg	mEq/L	0,75	0,75	1	-
Cl	mEq/L	108,75	110,75	108	-
Acetic Acid	mMol/L	3	3	2	-
Glucose	mg/dL	100	100	100	-
Bicarbonate	mEq/L	-	-	-	35

621-A
621-N
622-A

Dialysander 700 (5 L)

Dilution 1:35,83		721-A	722-A	723-A	724-A	700-B
Na	mEq/L	81	81	81	81	59
K	mEq/L	2	1,5	1,5	1	-
Ca	mEq/L	3,5	3	2,5	3,5	-
Mg	mEq/L	1	1	1	1	-
Cl	mEq/L	87,5	86,5	86	86,5	20

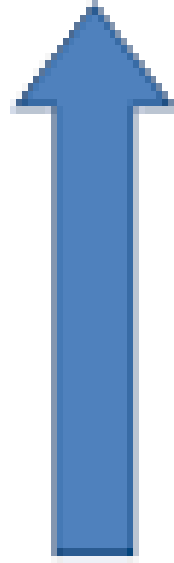
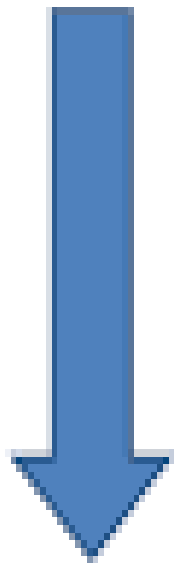
Blood

- $\text{Na}^+ = 140 \text{ mmol/L}$
- $\text{K}^+ = 5 \text{ mmol/L}$
- $\text{Cl}^- = 100 \text{ mmol/L}$
- $\text{HCO}_3^- = 21 \text{ mmol/L}$
- Urea = 22 mmol/L
- Creatinine = 450 mmol/L
- $\text{Ca}^{2+} = 1.2 - 1.4 \text{ mmol/L}$
- Phosphorus = 1.6 mmol/L
- Glucose = 5.6 mmol/L
- Albumin = 38 g/L

membrane

Dialysate

- $\text{Na}^+ = 140 \text{ mmol/L}$
- $\text{K}^+ = 2 \text{ mmol/L}$
- $\text{Cl}^- = 100 \text{ mmol/L}$
- $\text{HCO}_3^- = 35 \text{ mmol/L}$
- Urea = 0 mmol/L
- Creatinine = 0 mmol/L
- $\text{Ca}^{2+} = 1.25 \text{ mmol/L}$
- Phosphorus = 0 mmol/L
- Glucose = 5.6 mmol/L
- Albumin = 0 g/L



Dialysate

- Composition

- sodium	137-143
- potassium	0 - 4.0
- chloride	100 -111
- calcium	0 – 3.5
- magnesium	0.75 –1.5
- acetate	2.0 – 4.0
- bicarbonate	30 – 35 (result in fewer episode of hypotension)
- glucose (mg/dl)	0 – 0.25

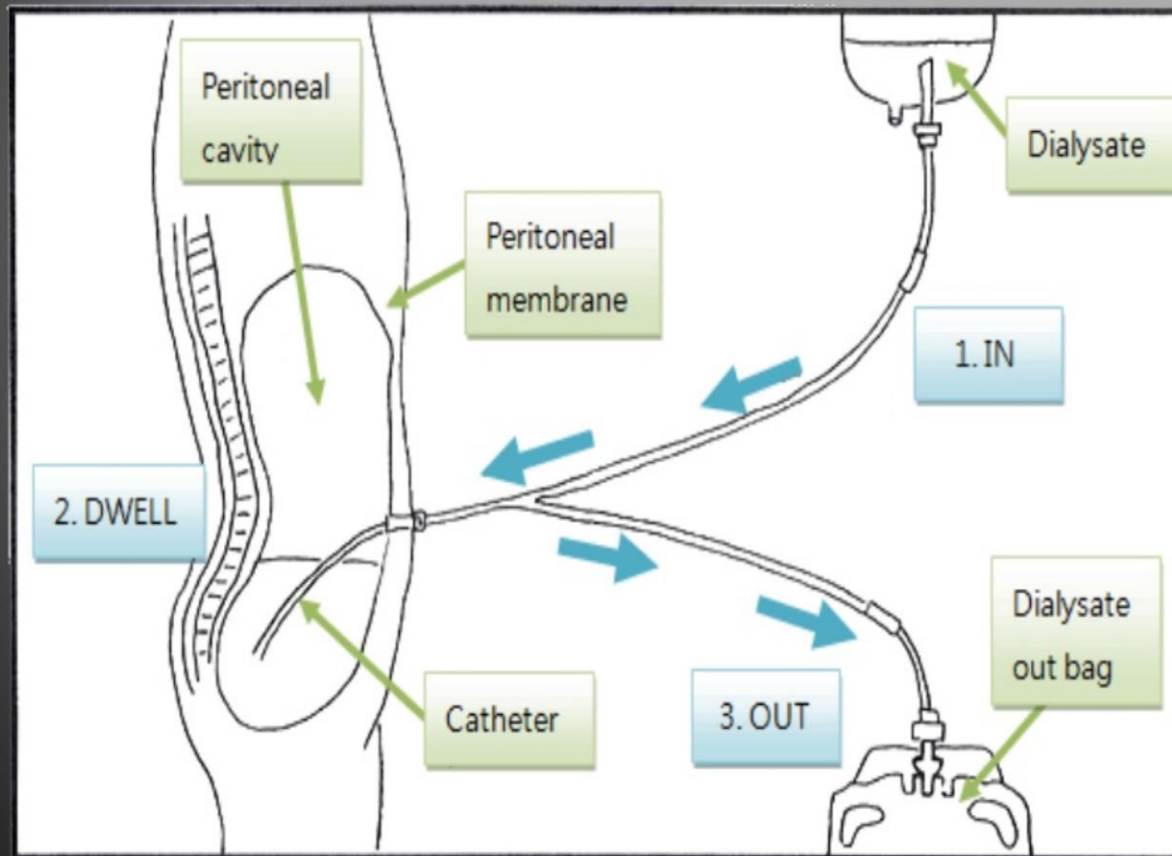
- Lower dialysate Na concentration are associated with a higher frequency of hypotension, cramping, nausea, vomiting, fatigue and dizziness.

Haemodialysis- complications

- Access complications:
 - Thrombosis
 - Infection
 - Lack of access
- Dialysis complication:
 - Reactions (hypersensitivity, inflammation)
 - Hypotension
 - Haemorrhage
 - Air embolism
 - Cardiac arrhythmias

Peritoneal Dialysis (PD)

Principle of PD Treatment



- **Combined time for inflow, dwell & drain**

- most commonly used is 1 hour
- inflow 10 minutes, dwell 30 minutes, outflow 20 minutes.. 2-L exchange volume, 48 L of fluid /day

- **Inflow**

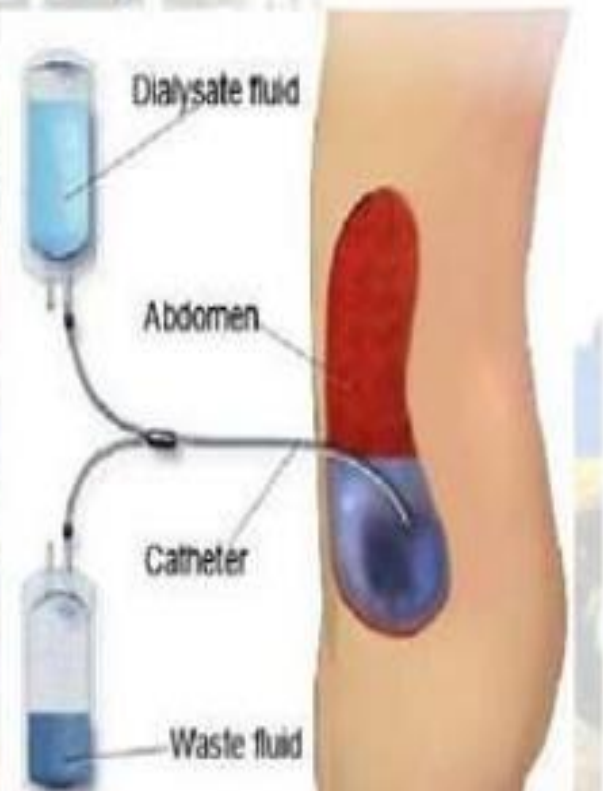
- 10 min.(200ml/min.)
- Depend on high-abdomen(manual)

- **Dwell**

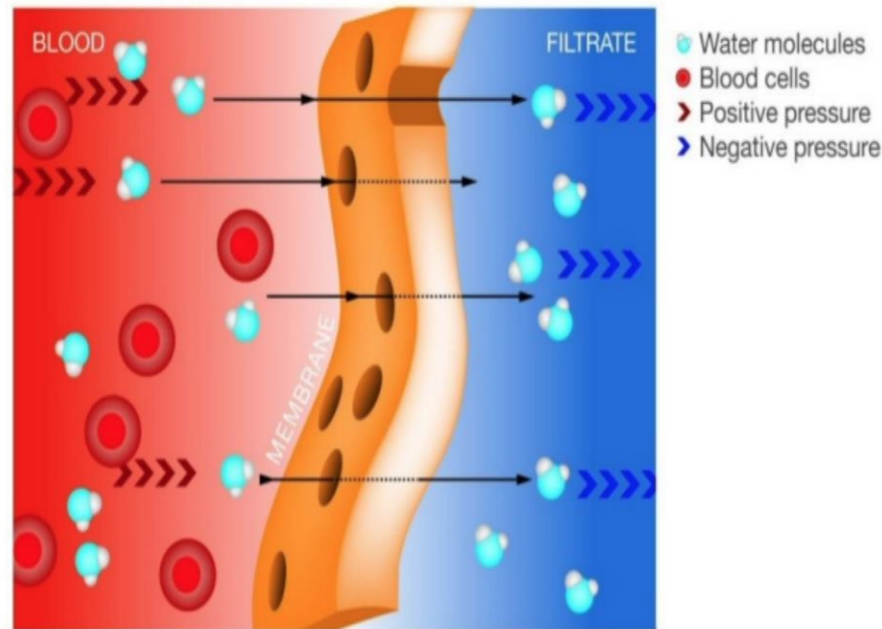
- Catabolic pt. : dwell 30 min.
- More stable pt.: longer dwell

- **Drain(outflow)** 20-30 min.depend on

- Total drained volume
- Resistance out flow

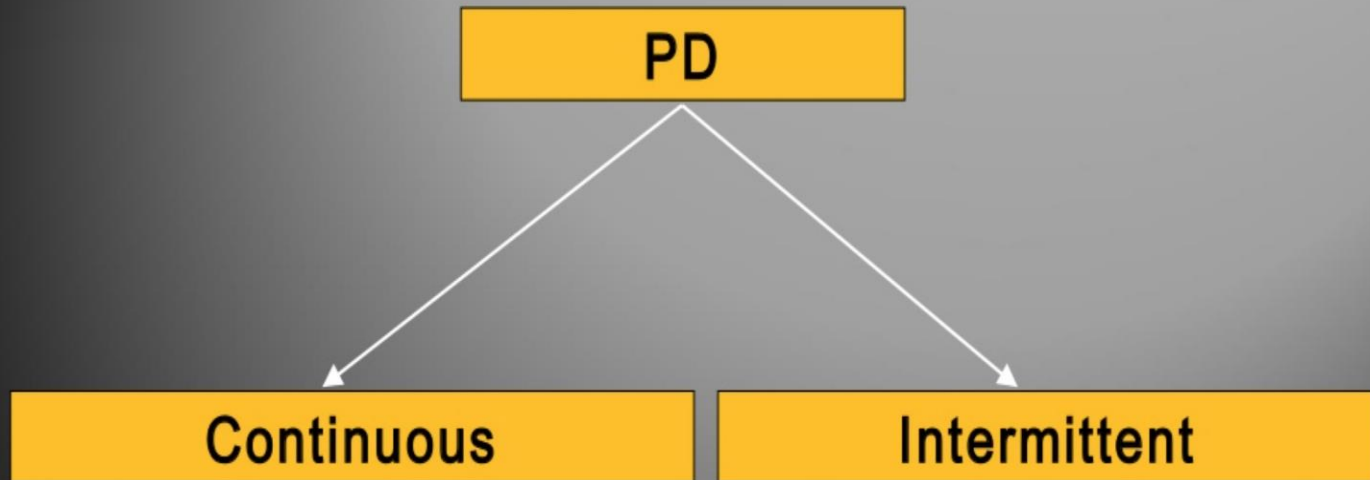


PD Treatment



- Abdominal cavity is lined by a vascular peritoneal membrane which acts as a semi-permeable membrane
- Diffusion of solutes (urea, creatinine, ...) from blood into the dialysate contained in the abdominal cavity
- Removal of excess water (ultrafiltration) due to osmotic gradient generated by glucose in dialysate

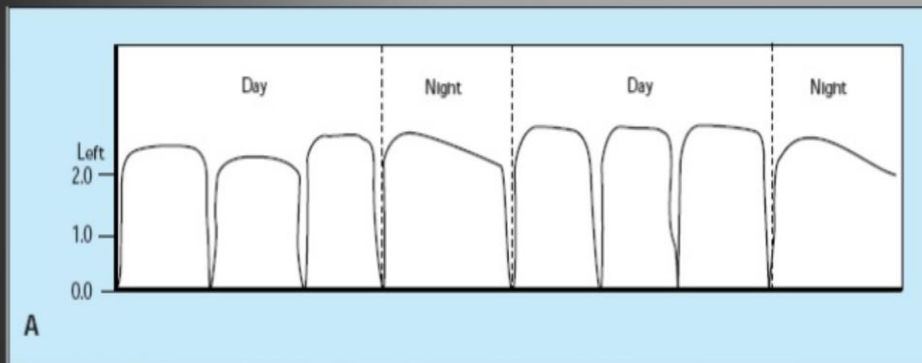
Peritoneal Dialysis (PD)



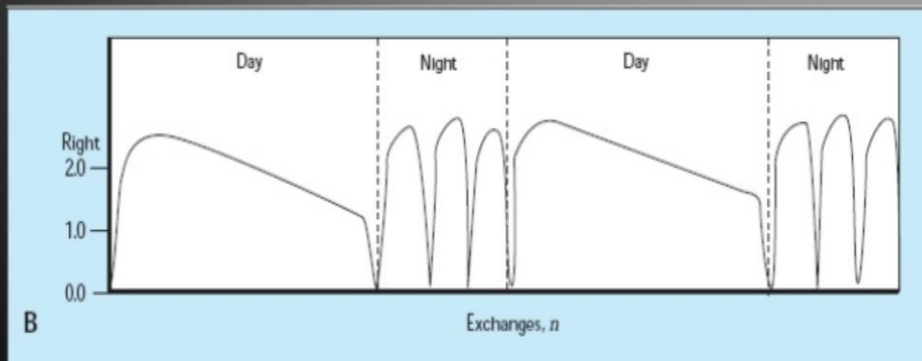
Continuous PD Regimens

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Multiple sequential exchanges are performed during the day and night so that dialysis occurs 24 hours a day, 7 days a week



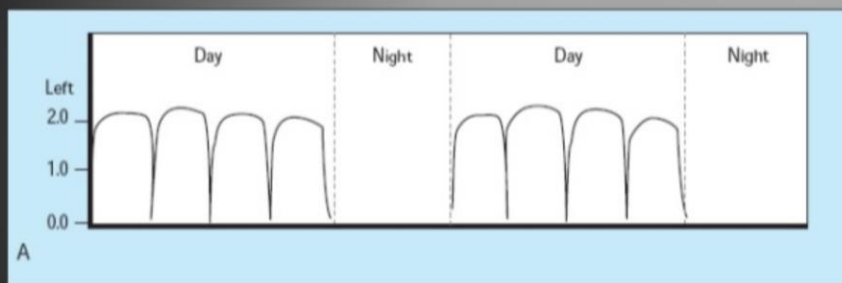
CAPD: Continuous Ambulatory PD



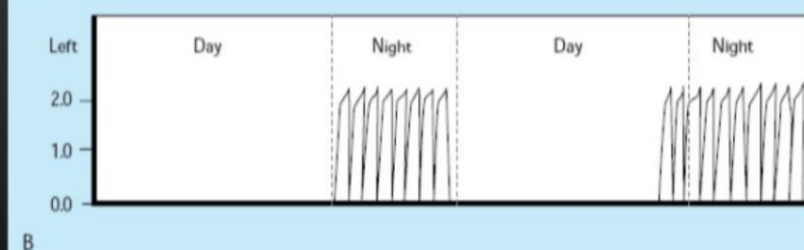
CCPD: Continuous Cyclic PD

Intermittent PD Regimens

PD is performed every day but only during certain hours



DAPD: Daytime Ambulatory PD.
Multiple manual exchanges during waking hours



NPD: Nightly PD.
Performed while patient asleep using an automated cyclor machine. Sometimes, 1 or 2 day-time manual exchanges are added to enhance solute clearances



Contra indications

Absolute contra indications

- Peritoneal fibrosis and adhesions following intra abdominal operations
- Inflammatory gut diseases





Relative contra indications

- Hernias
- Significant loin pain
- Psychosis
- Diverticulosis
- Colostomy
- Obesity
- Significant decrease of lung functions



Osmotic agents

- Low molecular weight
 - Glucose- 1.5%,2.5%,4.25%
 - Glycerol
 - Amino acids
- High molecular weight
 - Albumin
 - Glucose polymer
 - peptides

Composition of peritoneal dialysis fluid

Sodium(mmol/L)	132-134
Potassium(mmol/L)	0-2
Calcium(mmol/L)	1.0-1.75
Magnesium(mmol/L)	0.25-0.75
Chloride(mmol/L)	95-106
Lactate(mmol/L)	35-40
Bicarbonate(mmol/L)	34
Bicarbonate/lactate	25/15
Glucose(g/dl)	1.36-4.25
Icodextrin(g/dl)	7.5
Amino acids(g/dl)	1.1

Complications of Peritoneal Dialysis

- ▶ Peritonitis
- ▶ Catheter Infection
- ▶ Cuff erosion
- ▶ Abdominal hernias
- ▶ Abdominal distension
- ▶ Hypotension

- ▶ Hyperglycaemia
- ▶ Hyponatremia/ Hypernatremia
- ▶ Hyperkalaemia/Hypokalaemia
- ▶ Hypoalbuminemia
- ▶ Abdominal wall and pericatheter leak
- ▶ Genital edema
- ▶ Respiratory complications
- ▶ Back pain
- ▶ Dyslipidaemia

Advantages of Haemodialysis vs. Peritoneal dialysis



Haemodialysis

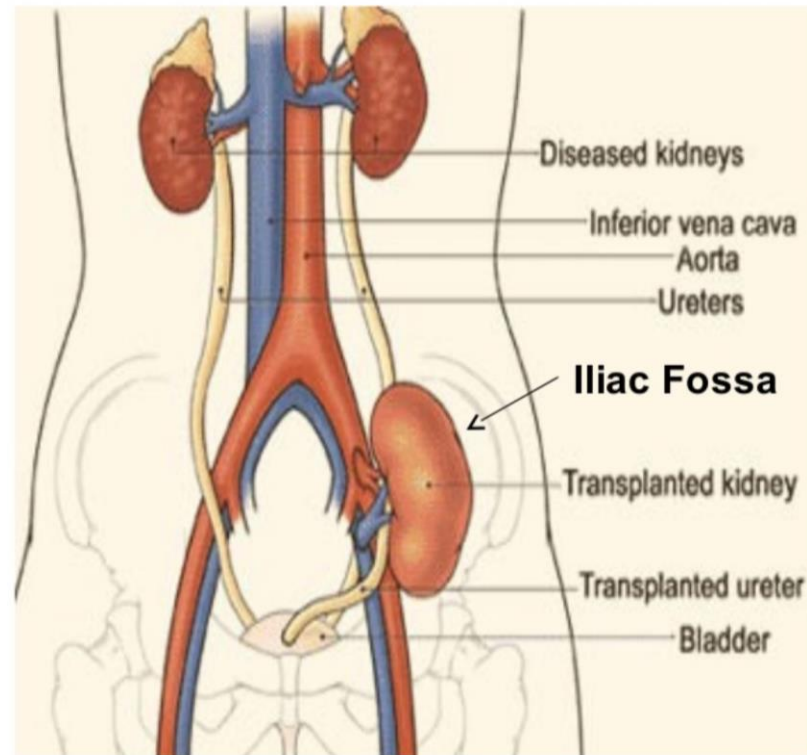
- Done by trained health professionals who can watch for any problems.
- Allows contact with other people having dialysis, which may give you emotional support.
- Not done by oneself, as with peritoneal dialysis.
- Done for shorter amount of time and on fewer days each week than peritoneal dialysis.

Peritoneal dialysis

- Gives you more freedom than hemodialysis.
- Can be done at home.
- You can do it when you travel.
- You may be able to do it while you sleep.
- You can do it by yourself.
- It doesn't require as many food and fluid restrictions as hemodialysis.
- It doesn't use needles.

Kidney Transplantation

Principle of Kidney Transplantation



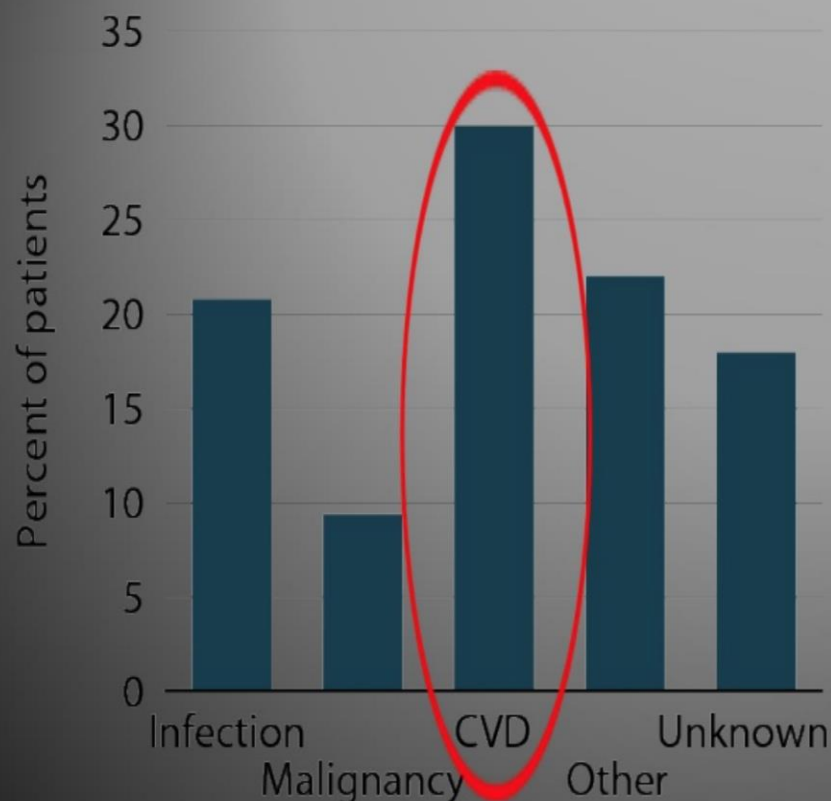
Eligibility

- ▶ Able to be evaluated once GFR <20 mL/min
- ▶ Need just one listing less than 20 mL/min to remain active
- ▶ With GFR 15-19 mL/min- can be transplanted if live donor or if six antigen match
- ▶ If GFR <15 mL/min- open to all offers
- ▶ Why starting early- if certain blood types with long wait time, no potential live donors

Absolute contraindications

- ▶ Active malignancy
- ▶ Advanced lung disease
 - Chronic O2 needs
 - FEV 1<1
- ▶ Ongoing infections
- ▶ Life expectancy less than 2 years
- ▶ Active substance abuse
- ▶ Ischemic Cardiac disease
 - Not amenable to revascularization
- ▶ Severe peripheral vascular disease
- ▶ Liver cirrhosis/primary oxalosis- unless combined liver/kidney
- ▶ Poorly controlled psychiatric illness
- ▶ Minimal rehabilitative potential
- ▶ Morbid obesity – BMI>40

Causes of Death in Kidney Transplant Patients with Functioning Graft 2006–2010



First-time, kidney-only transplant recipients, age 18 & older, 2006–2010, who died with functioning graft.

Key Concepts

- ▶ Kidney transplantation is the most cost-effective modality of renal replacement
- ▶ Transplanted patients have a longer life and better quality of life
- ▶ Early transplantation (before [pre-emptive] or within 1 year of dialysis initiation) yields the best results
- ▶ Living donor kidney outcomes are superior to deceased donor kidney outcomes
- ▶ Early transplantation is more likely to occur in patients that are referred early to nephrologists
- ▶ Refer for transplant evaluation when $\text{eGFR} \leq 20 \text{ mL/min/1.73m}^2$

Thank You