DIALYSIS TECHNIQUE-ADEQUACY

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QUESTION

- *A patient with progressive CKD has opted for hemodialysis for renal replacement therapy. Which type of vascular access is associated with better outcomes in hemodialysis patients?*

- *A. Central venous cuffed catheter*
- *B. Arteriovenous graft*
- *C. Arteriovenous fistula*
- *D. Temporary central venous catheter*

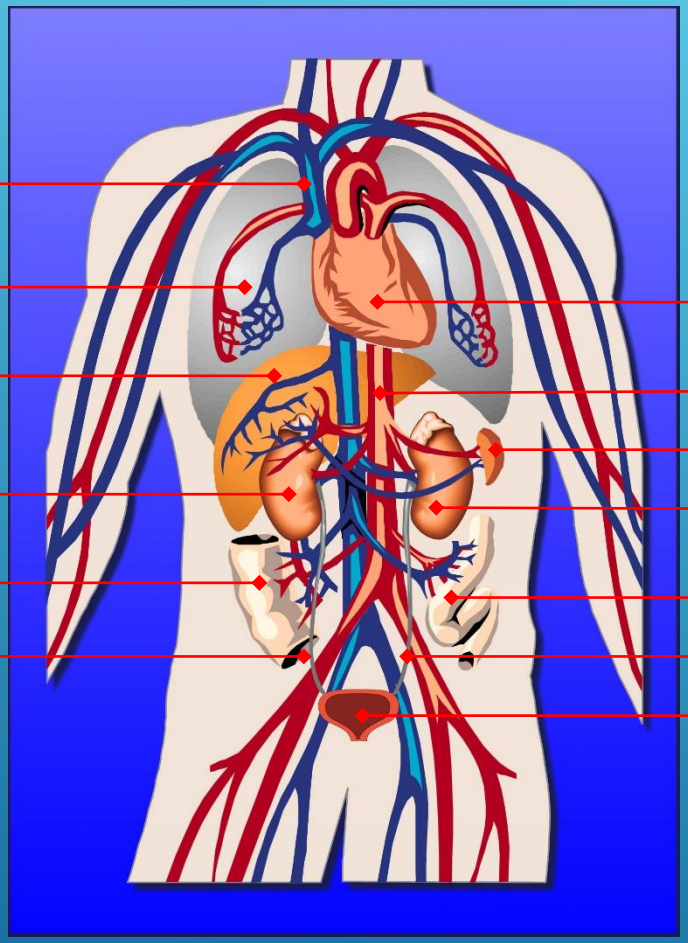
HEMODIALYSIS: A REVIEW

- History of Hemodialysis
- Principles &Techniques of Hemodialysis
- Vascular Access
- Complications of Hemodialysis
- Dose of Hemodialysis
- Continuous Therapies
- Peritoneal Dialysis
- Nutritional Issues
- The Future

PRINCIPLES &TECHNIQUES OF DIALYSIS

LOCATION AND STRUCTURE

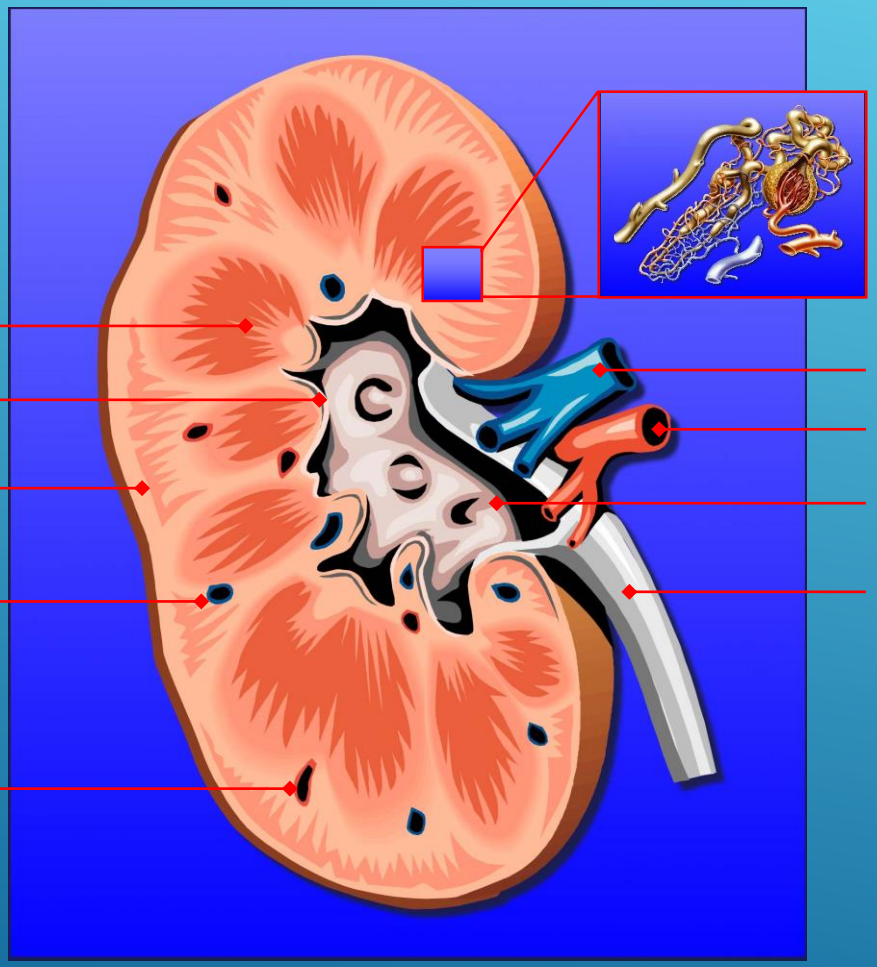
LOCATION OF THE KIDNEYS INSIDE OF THE BODY



Healthy Kidney | Diseased Kidney | Physical Basis | Renal Replacement

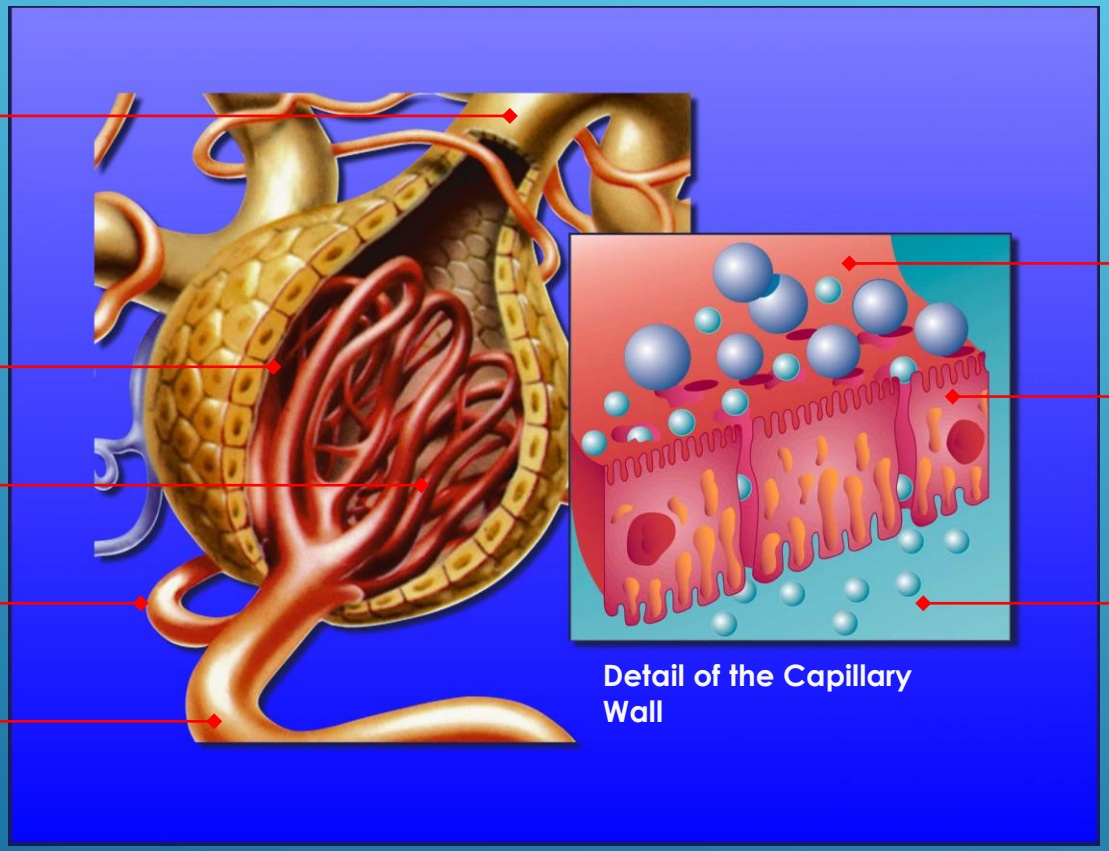
LOCATION AND STRUCTURE

CROSS-SECTION OF THE KIDNEY - A COMPLEX ORGAN



LOCATION AND STRUCTURE

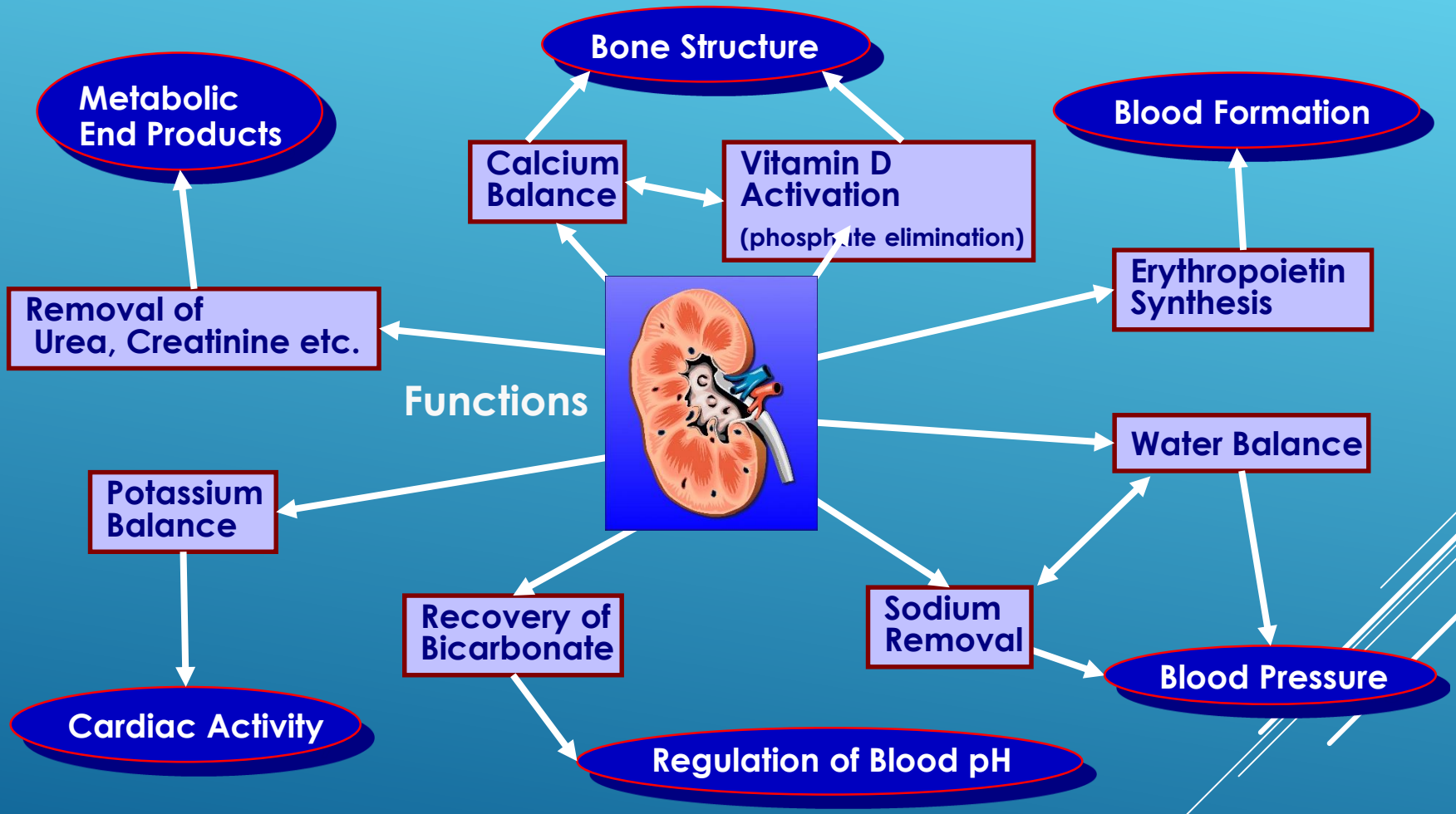
DETAILS OF A GLOMERULUS - THE MEMBRANE FOR FILTRATION



Average surface area per kidney is approx 0.3 m_2

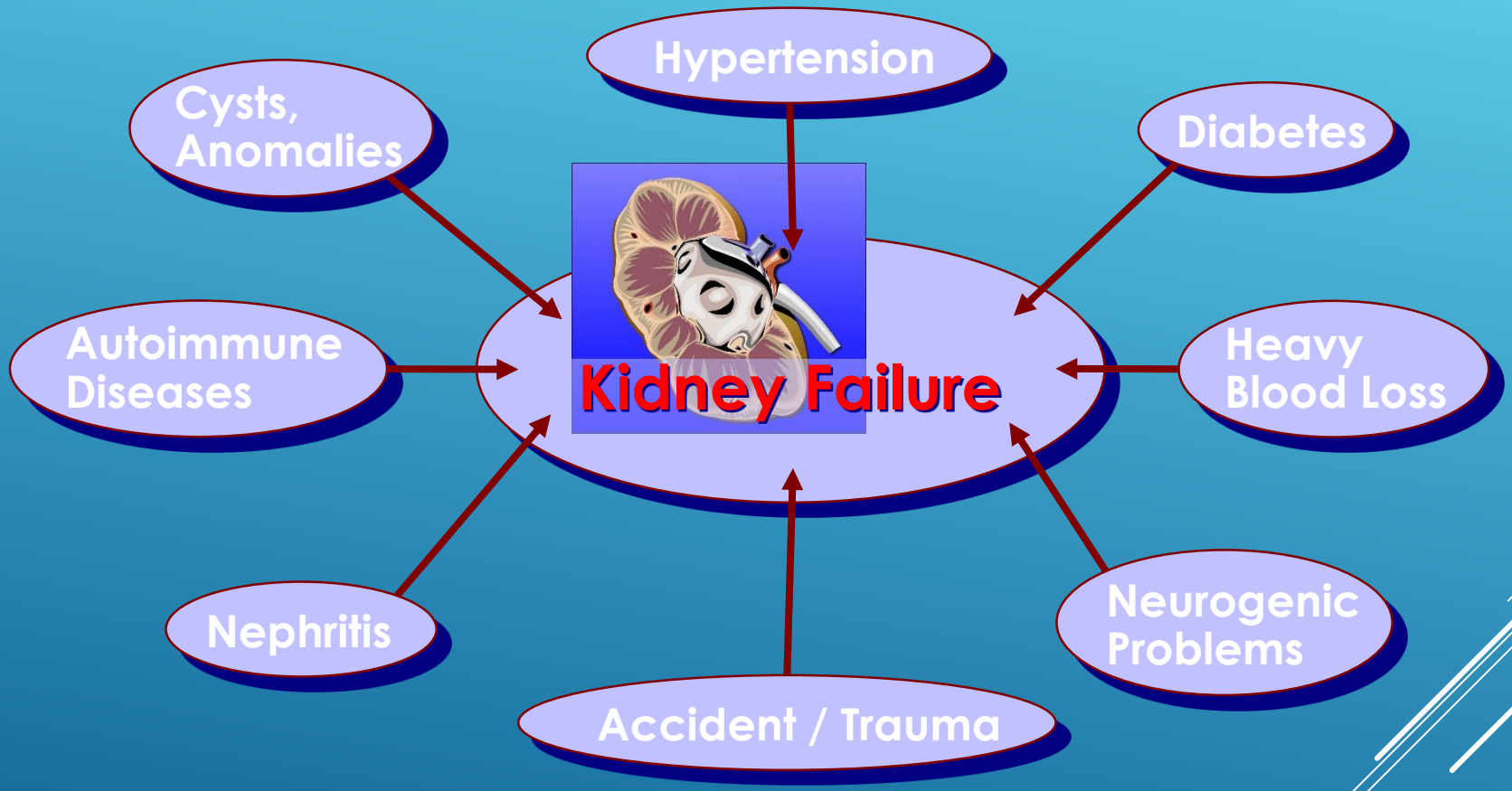
FUNCTIONS OF THE KIDNEY

MANIFOLD TASKS OF THE KIDNEY



CAUSES FOR RENAL DISEASES

EXAMPLES



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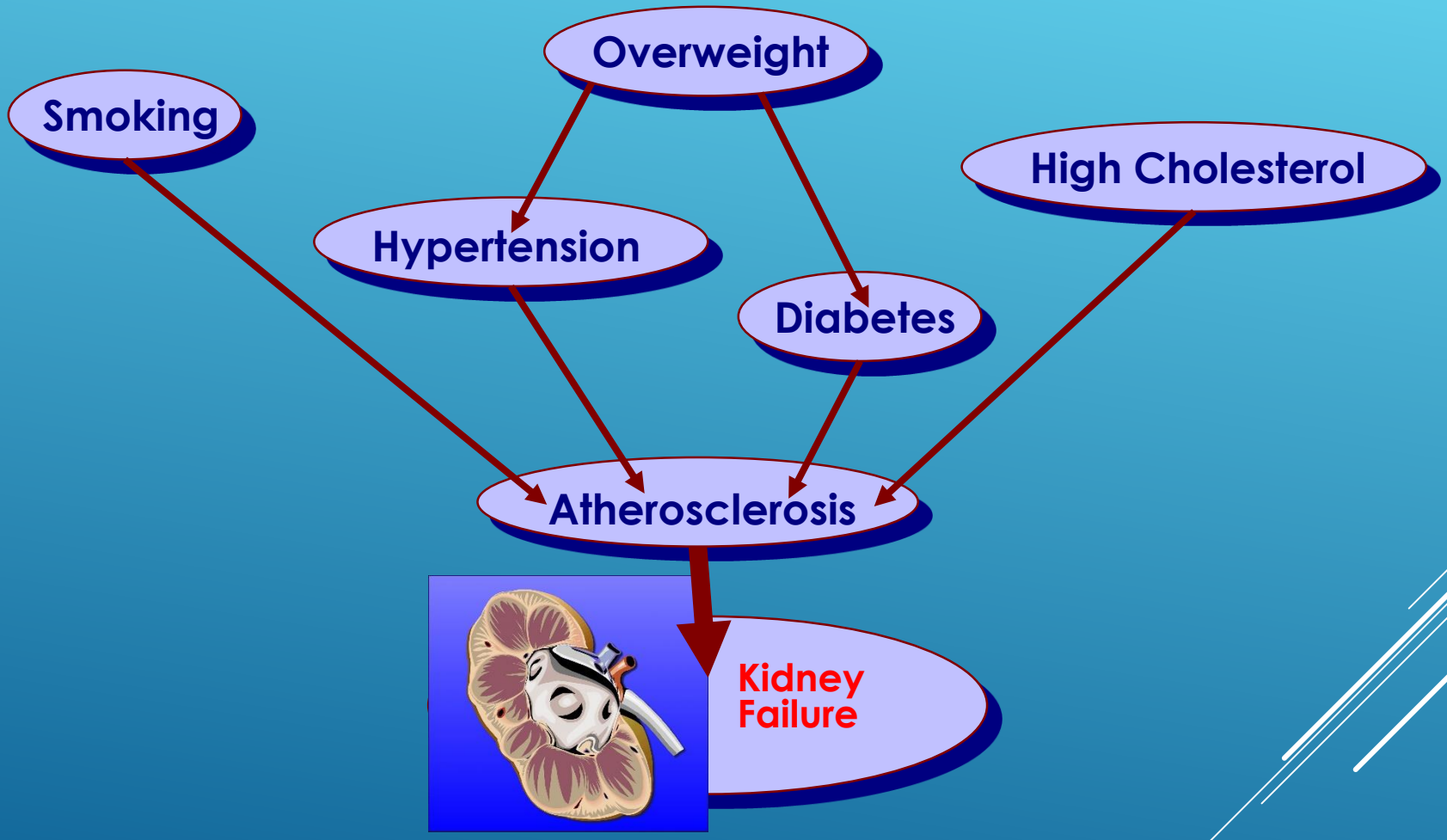
CAUSES FOR RENAL DISEASES

RISK FACTORS OF RENAL FAILURE



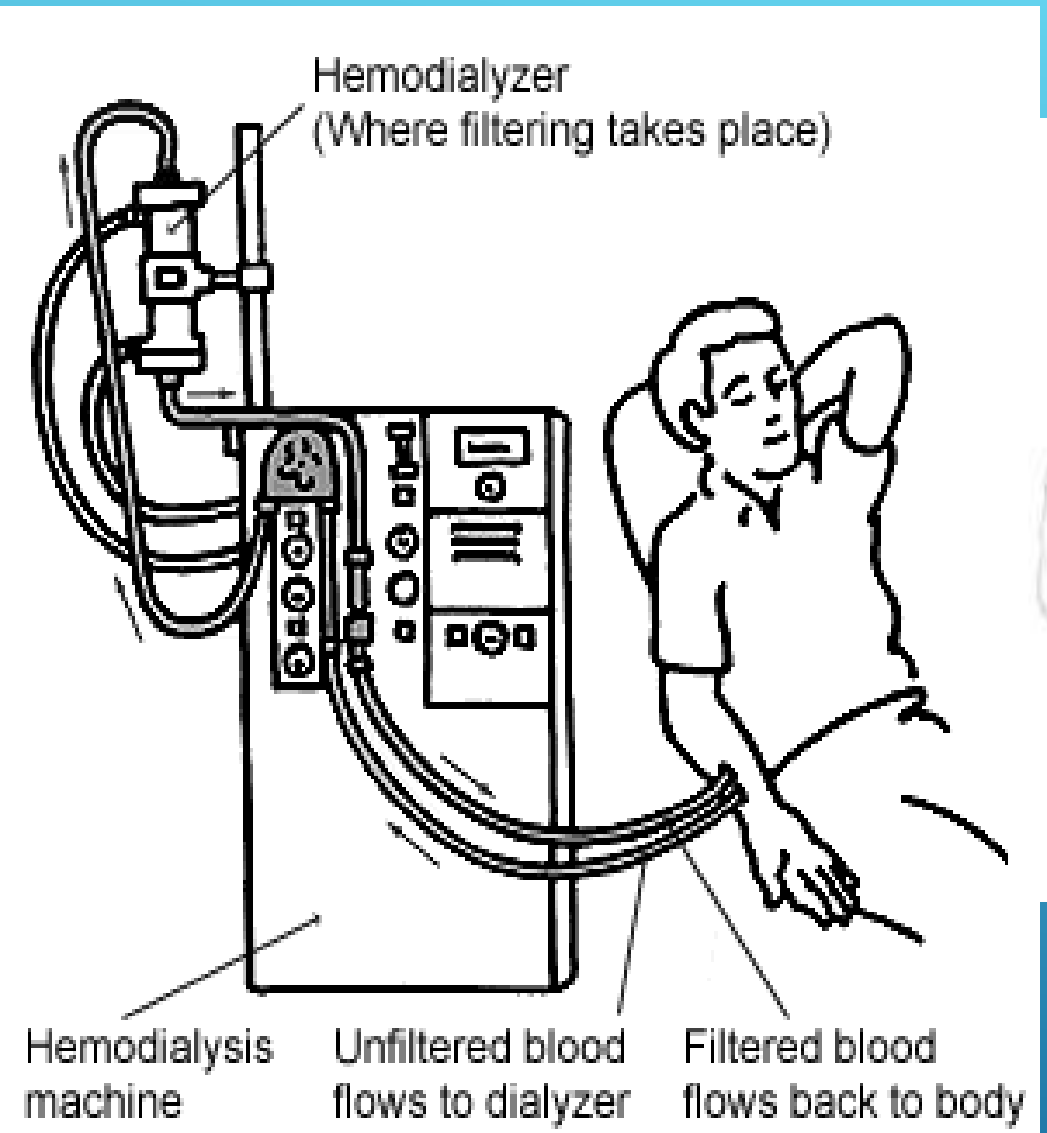
Healthy Kidney | Diseased Kidney | Physical Basis | Renal Replacement

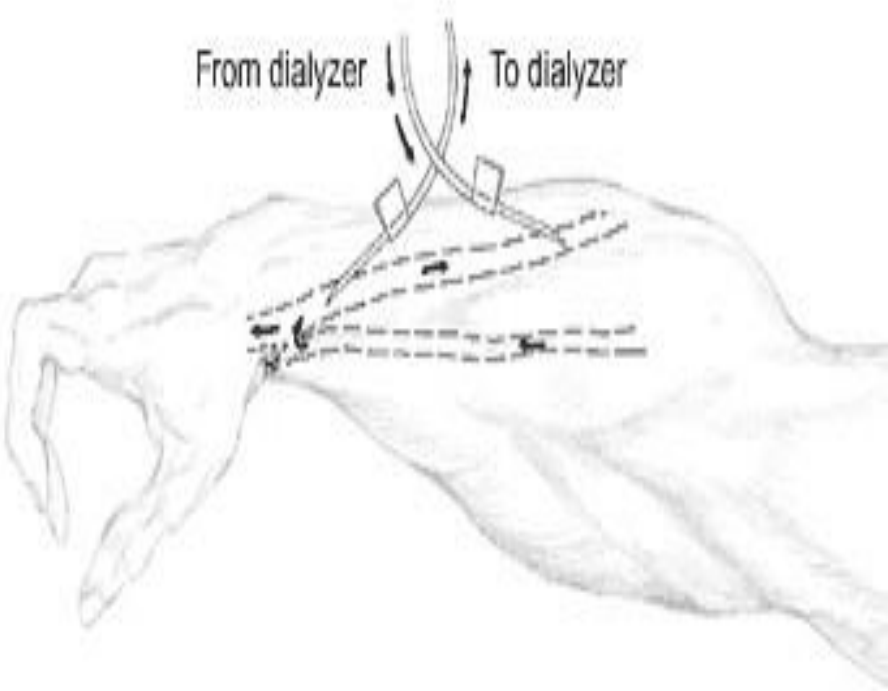
RENAL REPLACEMENT THERAPY: REPLACING KIDNEY FUNCTIONS

- Water balance
- Electrolyte balance
- Acid/Base balance
- Waste Removal (urea, creatinine)
- Endocrine functions
  - Vitamin D activation
  - Erythropoietin production

GOALS OF RRT

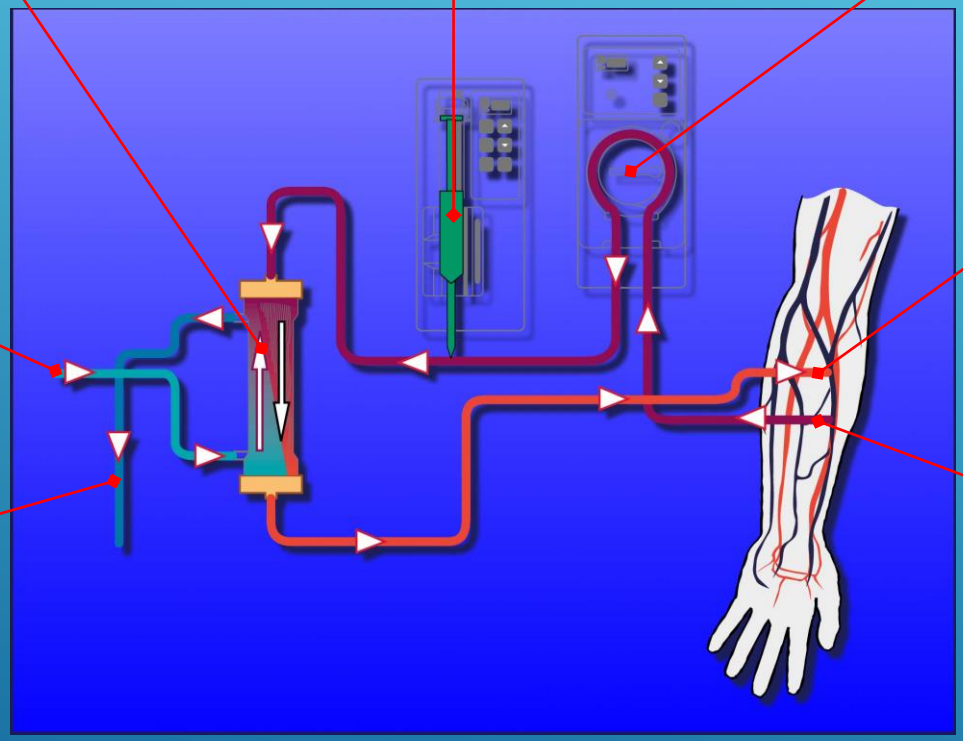
- Prolong Life
- Reverse uremic symptoms
- Optimize quality of life
- Maintain positive nitrogen balance
- Return to pre-end stage renal disease functional status
- Minimize patient inconvenience factors


Hemodialyzer
(Where filtering takes place)
Hemodialysis machine
Unfiltered blood flows to dialyzer
Filtered blood flows back to body


From dialyzer
To dialyzer

HEMODIALYSIS

FLOW SCHEME HEMODIALYSIS



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DIALYSIS

Process by which the solute composition of a solution “A” is altered by exposing it to a second solution “B” through a semi-permeable membrane

MECHANISMS OF SOLUTE TRANSFER

- Diffusion
- Osmosis
- Ultrafiltration
- Convection

DIFFUSIVE CLEARANCE

- A result of random molecular motion across a semipermeable membrane

Influenced by concentration gradient of the solute and its Molecular size, shape & weight, electrical charge and as well as by the membrane permeability to the solute

OSMOSIS

- Solute concentration vice versa of Solvent Concentration
- Across a semipermeable membrane solvent flow from higher concentration towards lower concentration called Osmosis.

ULTRAFILTRATION

- The movement of solvent(water) molecules across a semipermeable membrane , caused by a pressure gradient is called Ultrafiltration.
- Hydrostatic UF by hydrostatic pressure
- Osmotic UF by osmotic pressure.

CONVECTIVE CLEARANCE

- Water molecules passing through a SPM carry with them the solutes in their original concentration. This is called the "solvent drag phenomenon"
- Water can be made to move across a SPM by the application of either a hydrostatic or an osmotic gradient
- The convective transport of a solute depends on porosity of the SPM called Sieving Coefficient of the membrane.
- Sieving Coefficient of SPM=Conc .Of solute onside A /Conc. Of solute on side B

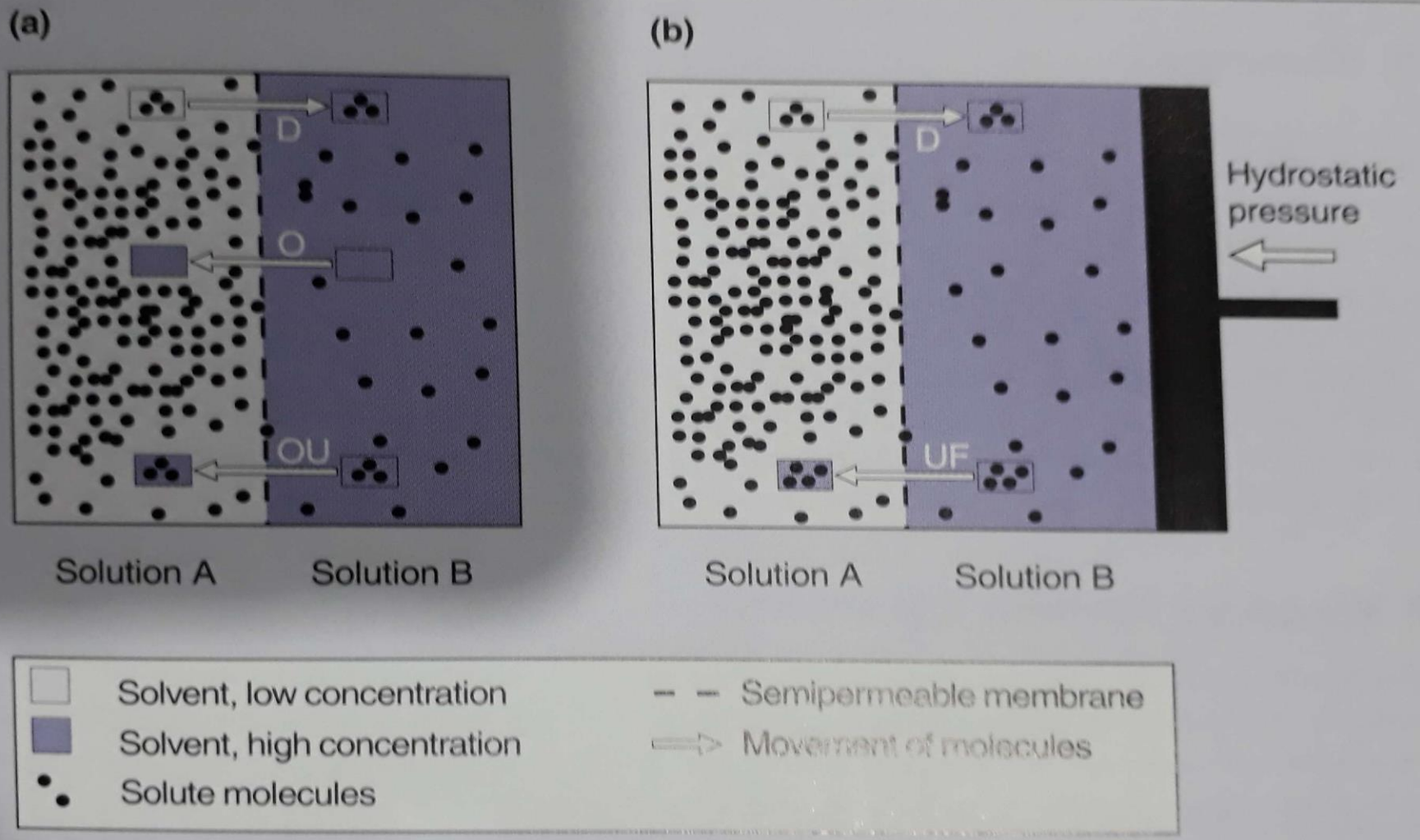
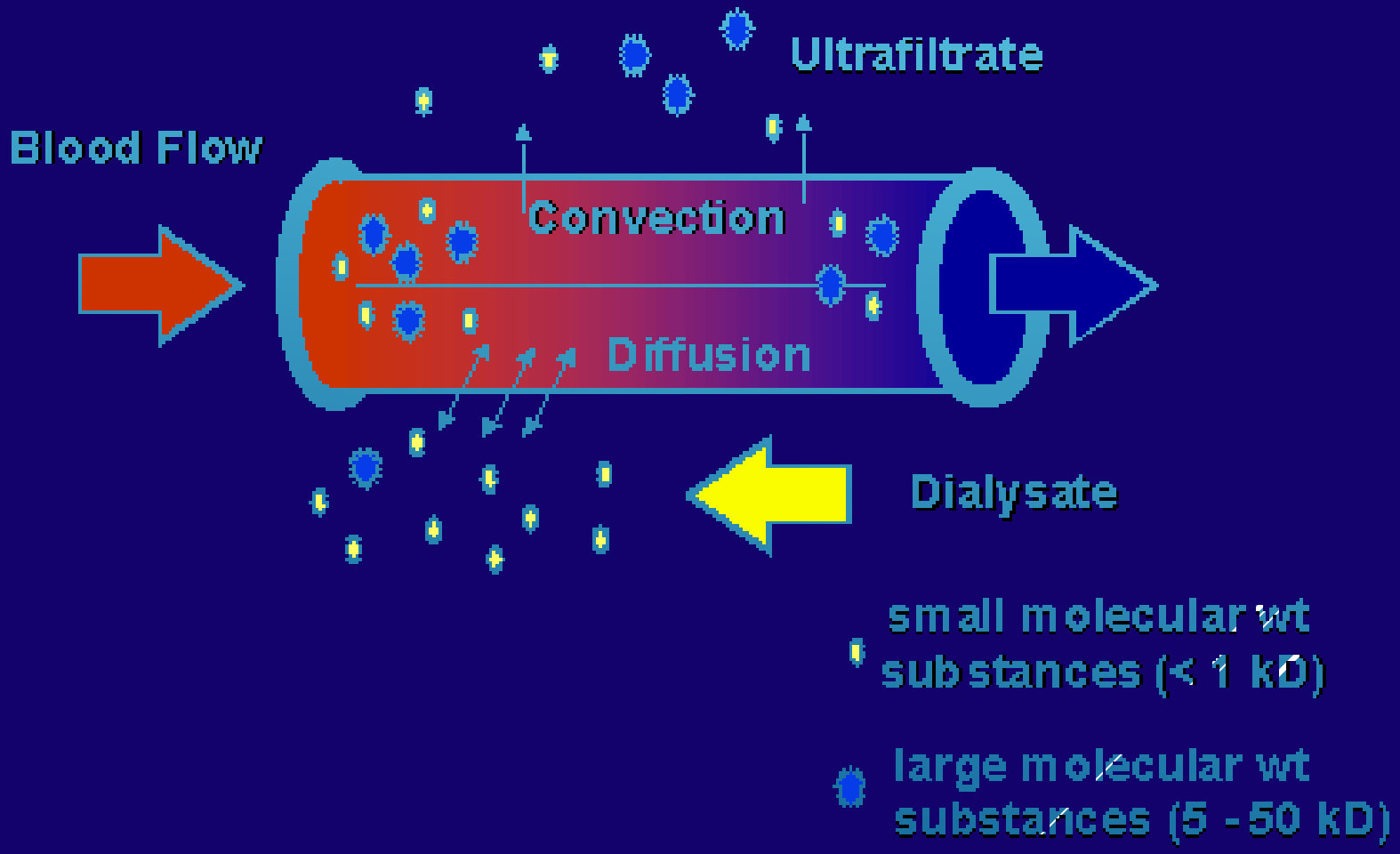
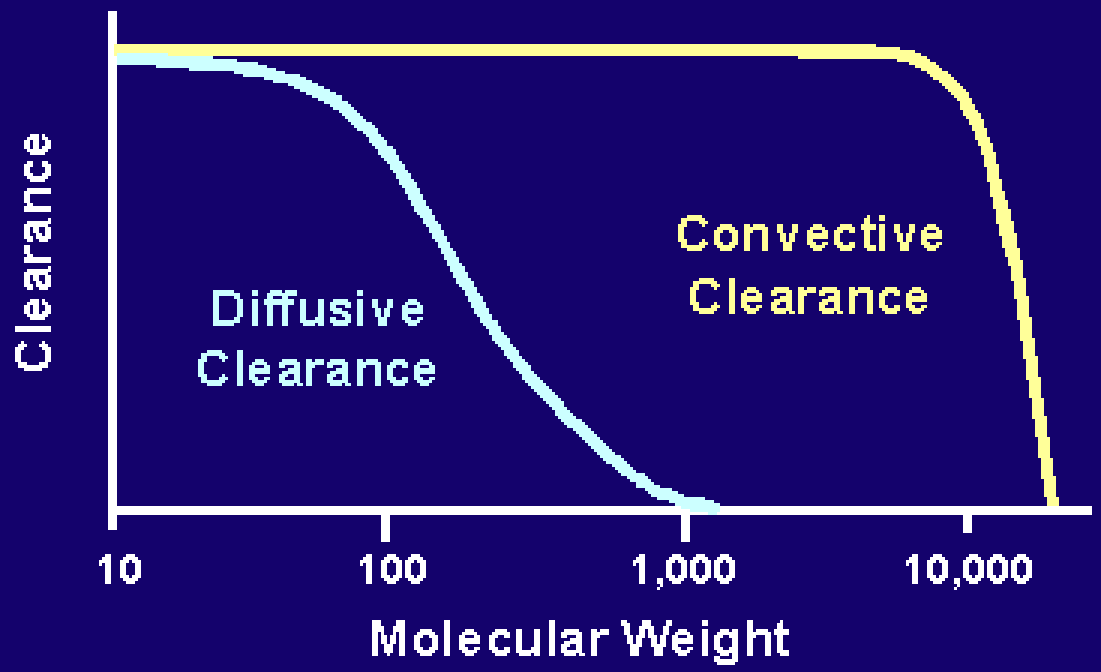


Figure 1.1. a) Diffusion, osmosis and osmotic ultrafiltration by convection (solvent drag). **b)** Hydrostatic ultrafiltration by convection. D, diffusion; O, osmosis; OU, osmotic ultrafiltration; UF, ultrafiltration.

Convection vs. Diffusion



Convection vs. Diffusion



CLEARANCE

- The vol. of blood or plasma from which the solute is completely removed in unit time.
- Clearance measures the magnitude of blood cleaning, independent of concentration of the solute entering the dialyzer.

BLOOD VS PLASMA CLEARANCE

- Plasma water is 93% of the plasma volume depending on plasma protein concentration.
- During transit across dialyzer most solutes are removed from plasma water.
- The clearance of the solute decreases as the Hematocrit increases(as plasma water decreases).
- Urea as often used as a solute to measure dialysis efficiency. Not affected by Hct.

EXAMPLE

Qb = 200 ml/minute, hematocrit = 35%

Plasma flow rate = 200 × (1 − 0.35) = 130 ml/minute

Plasma water flow rate = 130 × 0.93 (93% of plasma is water) = 121 ml/minute

Erythrocyte flow rate = 200 − 130 = 70 ml/minute

Erythrocyte water flow rate = 70 × 0.80 = 56 ml/minute (About 80% of erythrocyte volume is water [containing diffusable urea])

Thus the whole blood water flow rate effective for urea clearance = 121 + 56 = 177 ml/minute

If the blood water concentration of urea = 100 mg/dl at inlet and 10 mg/dl at outlet, the urea clearance of whole blood = 177 ml/minute × (1 − [{10mg/d} / {100 mg/dl}]) = 159 ml/minute

This means that 159 ml of blood is cleared of urea each minute.

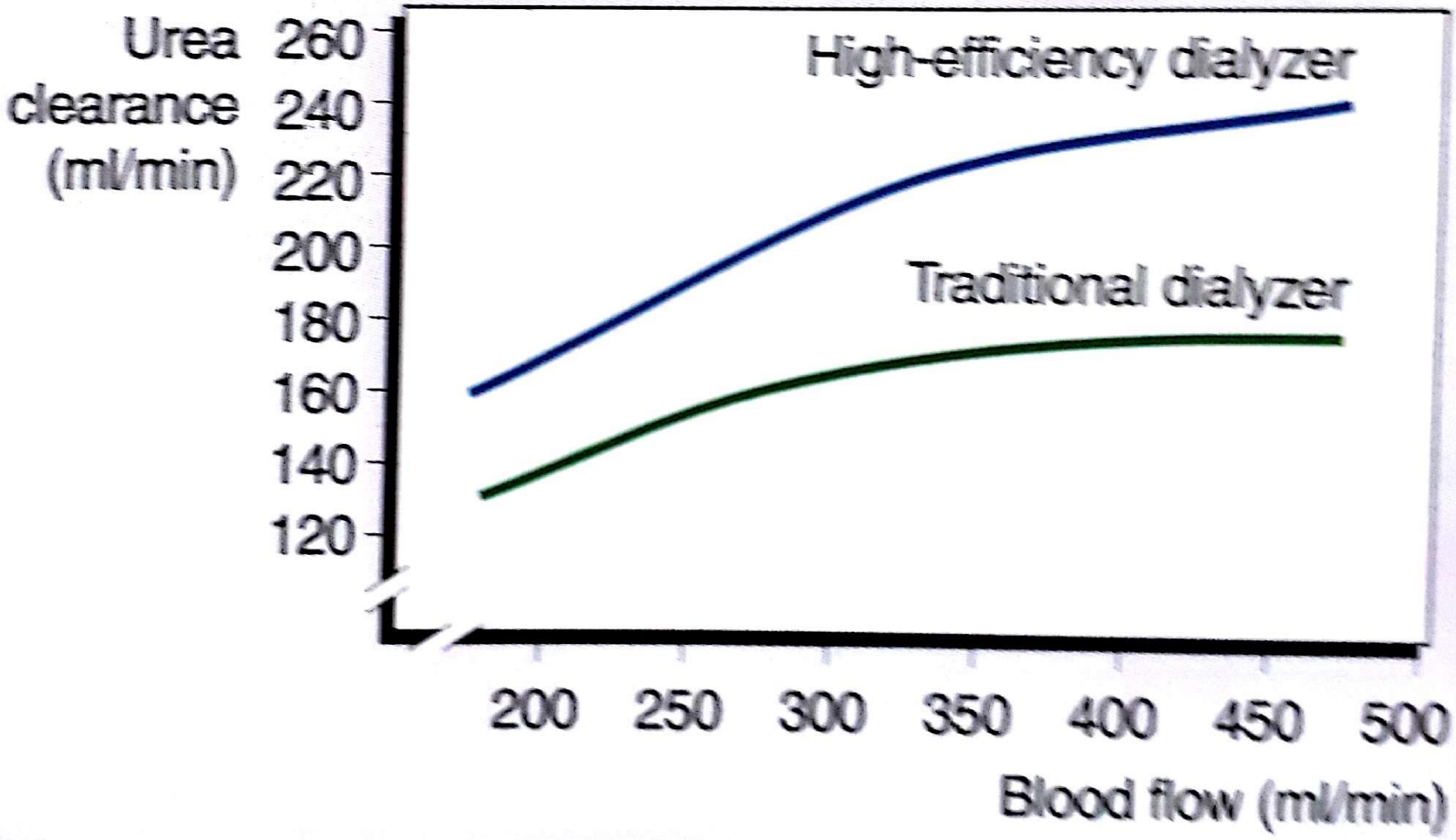
CLINICAL FACTORS INFLUENCING DIALYSIS UREA CLEARANCE

- Blood flow rate (Qb)
- Dialysate flow rate (Qd)
- Dialysis efficiency

BLOOD FLOW RATE

- The Urea clearance increases as Qb increases from zero but at faster rates the dialyzer efficiency decreases & Urea conc. At outlet increases.
- The Urea removed as a %age of Urea inflow into the Dialyzer decreases and (clearance is Qb multiplied by the fractional decline in urea) the clearance Curve is Plateaus.

Relationship Between Dialyzer Blood Flow and Urea Clearance



DIALYSATE FLOW RATE

- The increase in Qd increases the Urea clearance.
- This effect is negligible as long Qd is 150-200ml/min faster than Qb
- With high efficiency dialyzers < 10% increase in Urea clearance if Qd 500 ml/min to 800ml/min (Qb remains 350ml/min)

DIALYZER EFFICIENCY

- Dialyzer efficiency is measured in terms of clearance at a given Qb & Qd, usually for Urea at Qb of 200 ml/min & Qd of 500ml/min.
- Another measure of Dialyzer efficiency is solvent removal i-e UF Coefficient (Kuf).
- More accurate is Mass Transfer Co-efficient(KoA).
- The KoA of a solute is defined as the ability of a membrane to allow the transfer of a solute through its pores.
- The higher the value of KoA , the more permeable the membrane for that solute.

DIFFERENT HEMODIALYSIS TECHNIQUES

- Traditional Hemodialysis
- Hemofiltration
- Hemodiafiltration
- Ultrafiltration

TRADITIONAL HEMODIALYSIS

- Blood & Dialysate flow in opposite directions at dialyzer membrane to maximize the solute movement(counter current flow)
- Diffusion is the predominant method of solute clearance.
- Very small amount of Hydrostatic UF to remove excess fluid volume(2-3L) gained between dialysis session.

HEMOFILTRATION

- HF employs a large quantity of hydrostatic UF.
- Plasma ultra-filtrate is replaced with plasma –like electrolyte solution.
- Solute removal is achieved by convection(solvent drag), and volume control by the diff. bet. the volume removed & the volume replaced.
- This techniques can intermittent (IHF) or slow & continuous (CHF).
- CHF used in AKI . e g CAVH , CVVH(DLC).

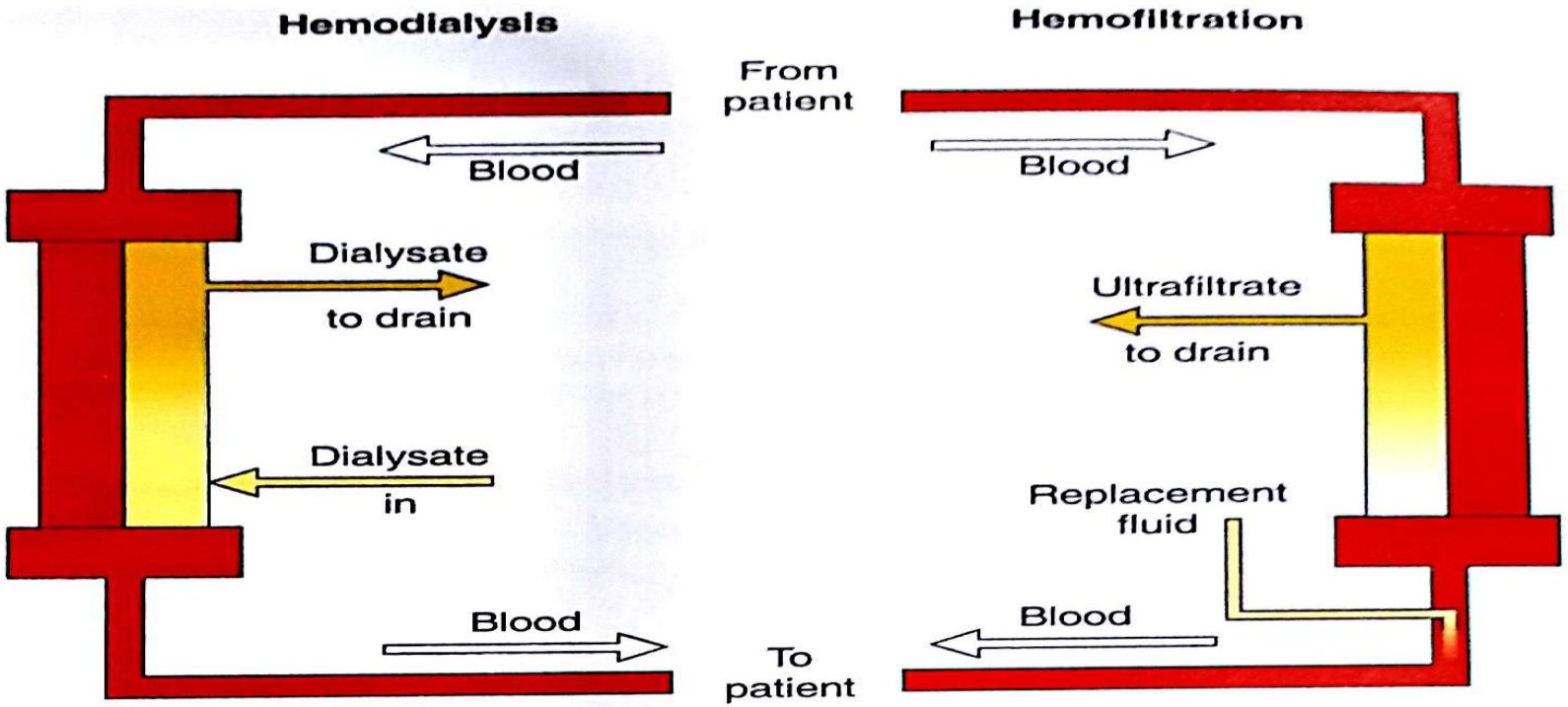
HEMODIAFILTRATION

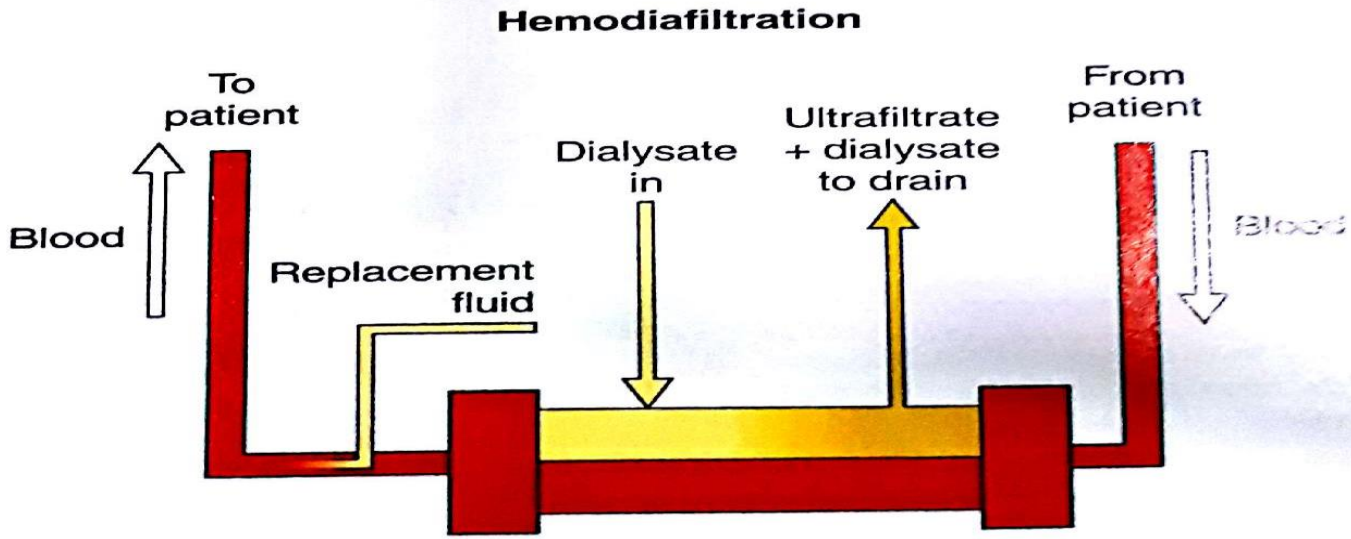
- To improve solute clearance , Hemofiltration(convective transport) may be combined with Hemodialysis(diffusive transport) by allowing Dialysate to flow on the UF side.
- Intermittent (HDF), Continuous (used in AKI) is called CAVHDF, CVVHDF depending on the site of the catheter.

ULTRAFILTRATION

- If volume removal only needed then we can use
- Intermittent UF(IUF)
- Slow and Continuous UF (SCUF), without replacement of ultrafiltrate.

Dialysis Techniques





HEMODIALYSIS SET-UP

- Hemodialysis apparatus can be divided in TWO major components

1-Blood circuit.

2-Dialysate circuit.

BLOOD CIRCUIT

- It comprises

1. Tubing set with ports, drip chambers and an access device
2. Blood pump
3. Hemodialyzers.

TUBING SET

- Blood drawn from the patient either via venous catheter or needle inserted into vascular access(fistula or graft).
- Tubing has two segment;

1. Arterial segment carried blood from patient to the Hemodialyzer.
2. Venous segment carries blood from dialyzer back to the patient.

- Each segment has a drip chamber where any air rises to top blood flows in these tubings.

TUBING SET

Pressure in these segments is monitored set with a alarm sound if it goes beyond the set range & blood pump stops.

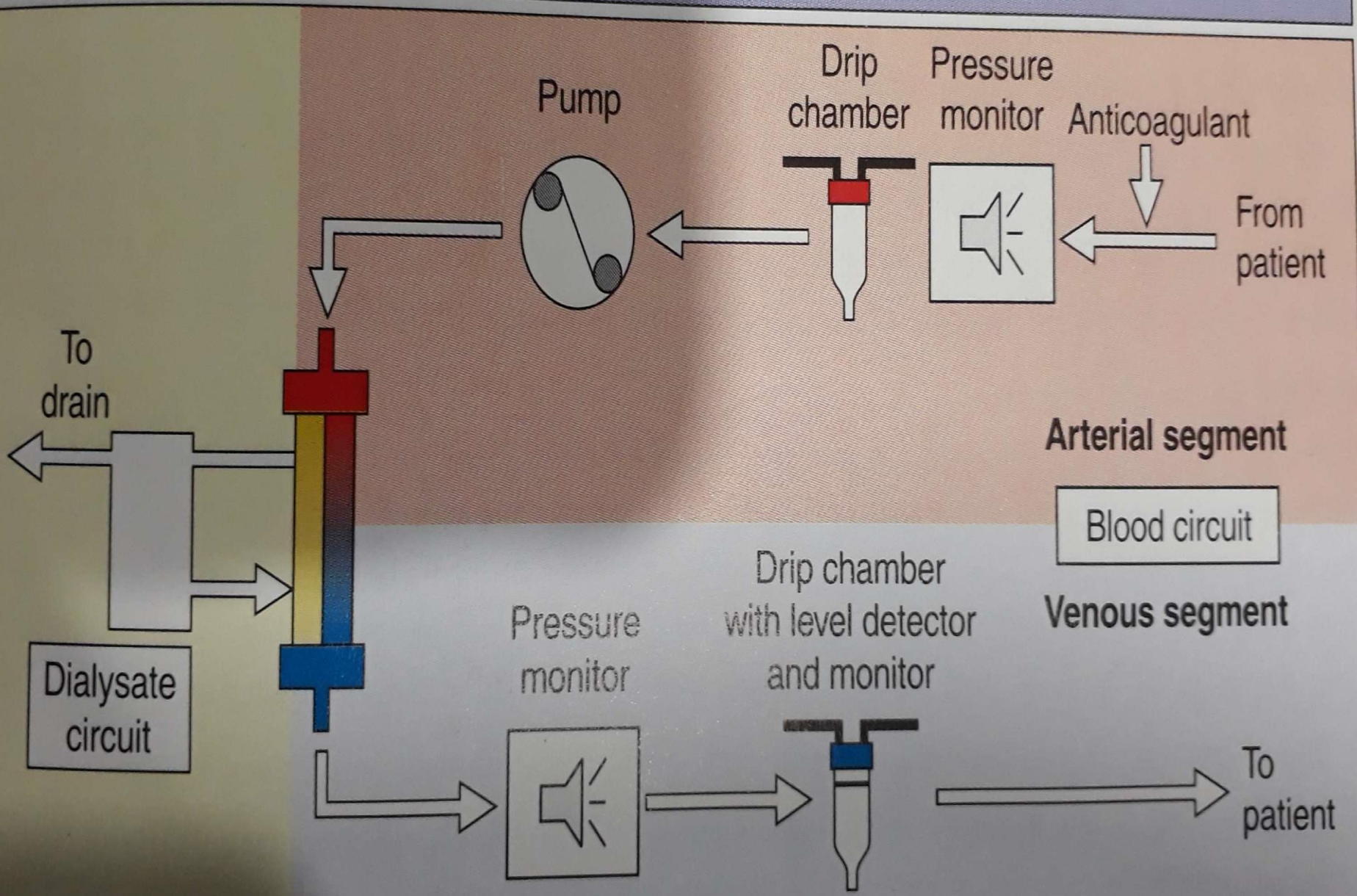
- Venous drip chamber has level detector. If the blood level drops below this level due to air, alarm sounds, the pump stops and tubing segment below drip chamber clamped to prevent any air entry into patient blood.
- Some have additional drip chambers for reading different pressures between blood pump & dialyzer.

BLOOD PUMP

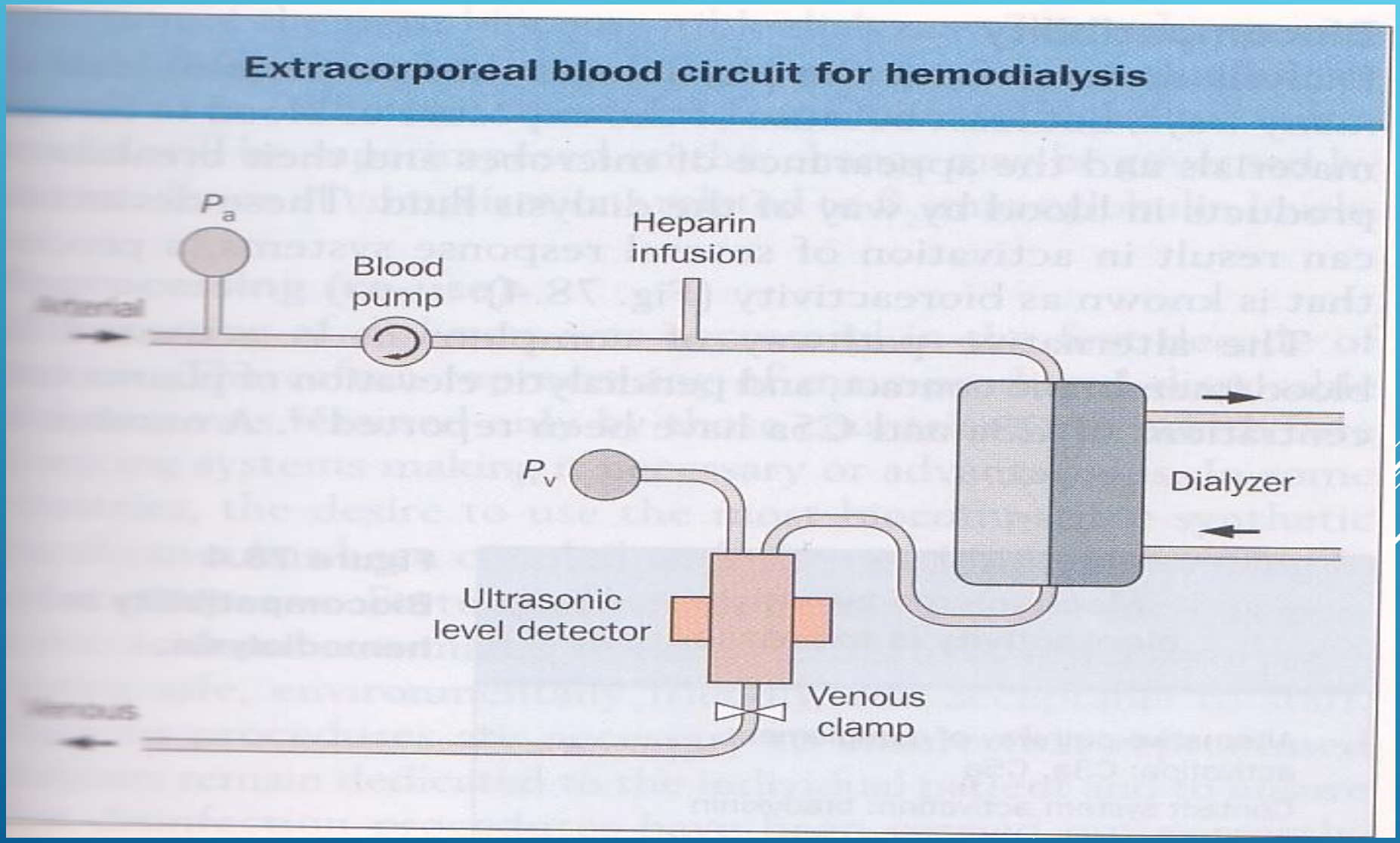
- The most common pump is Roller design, rotating rollers compresses the pump segment of the tubing & sweep the blood forward.
- The speed of rotation is Qb ranged from 200-500ml/min (median rate 350ml/min.
- There are two access related reasons for insufficient blood flow –

1. Arterial segment is not receiving the desired blood flow causing pump negative pressure usually set at -200 mmHg set alarm sounds
2. Venous side cant return the flow back to the patient causing pressure > 200 mm Hg in drip chamber– unsafe.

Hemodialysis Set-up

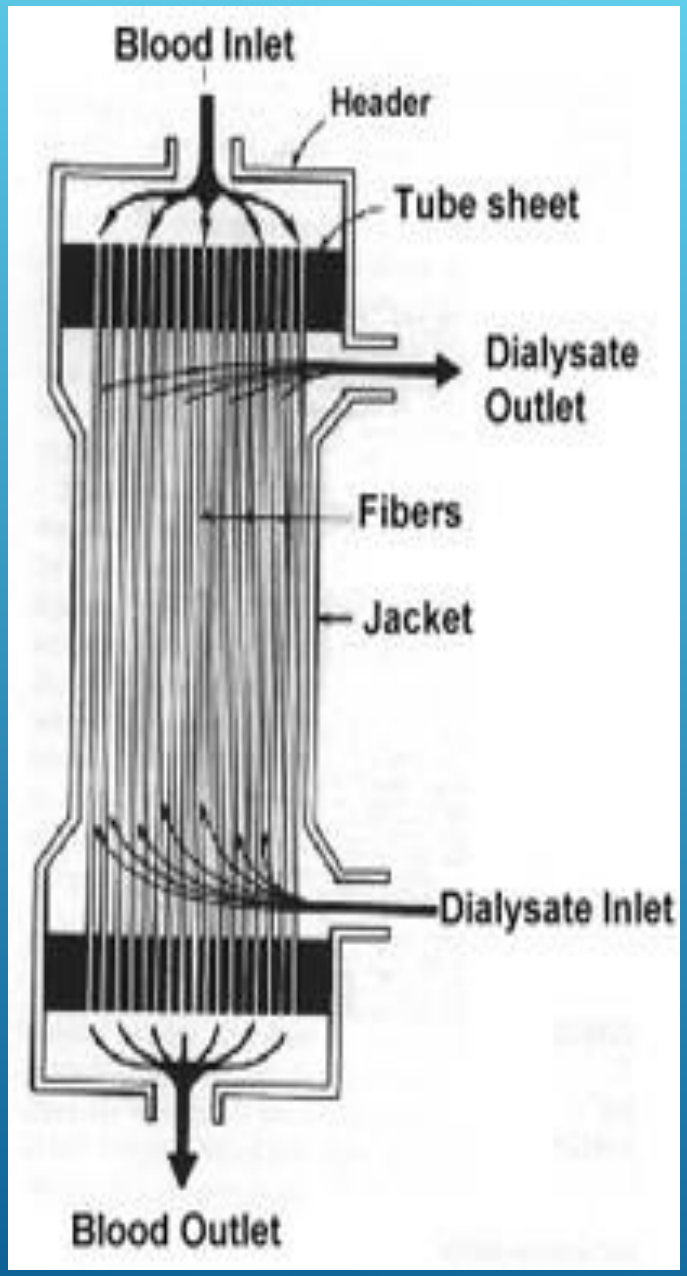


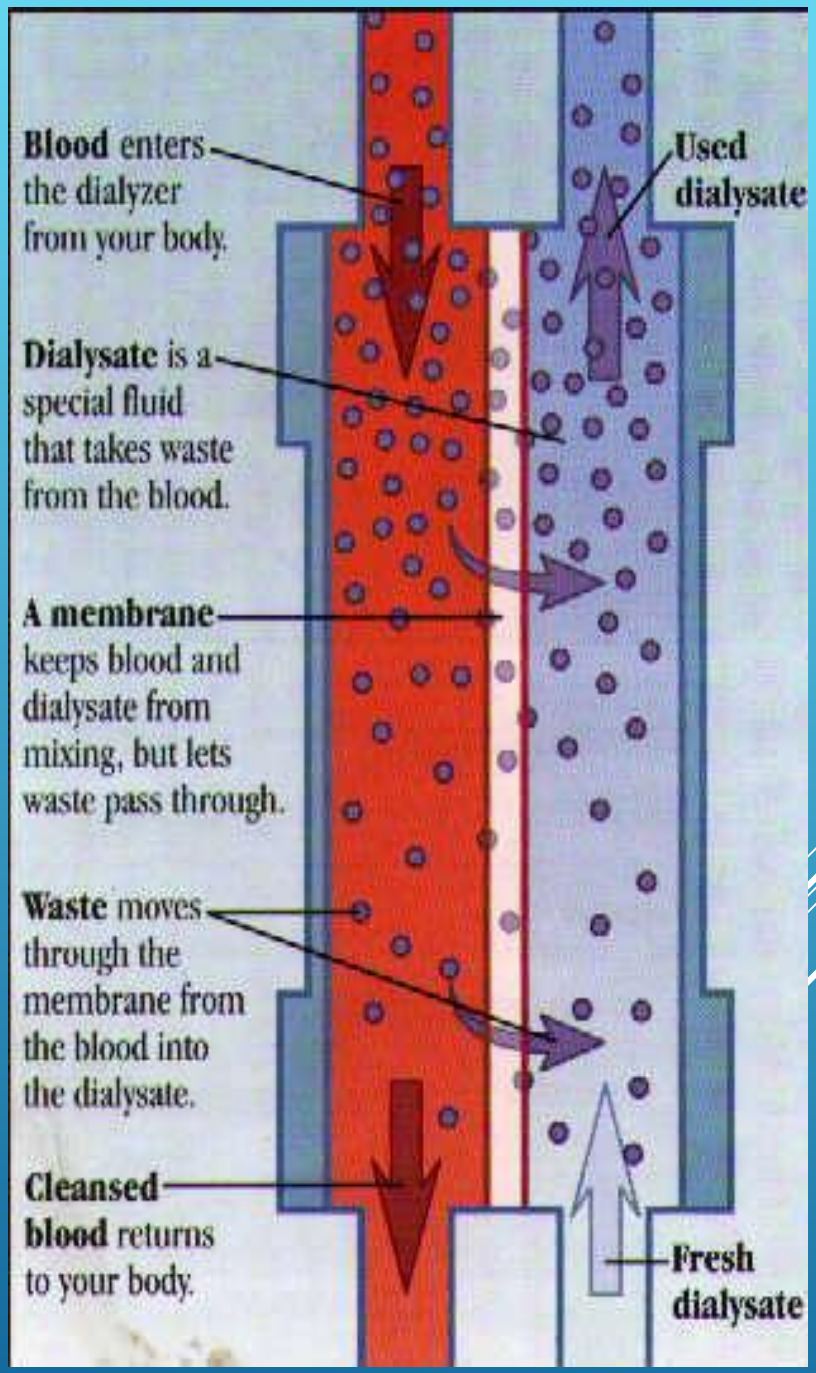
THE HEMODIALYSIS CIRCUIT



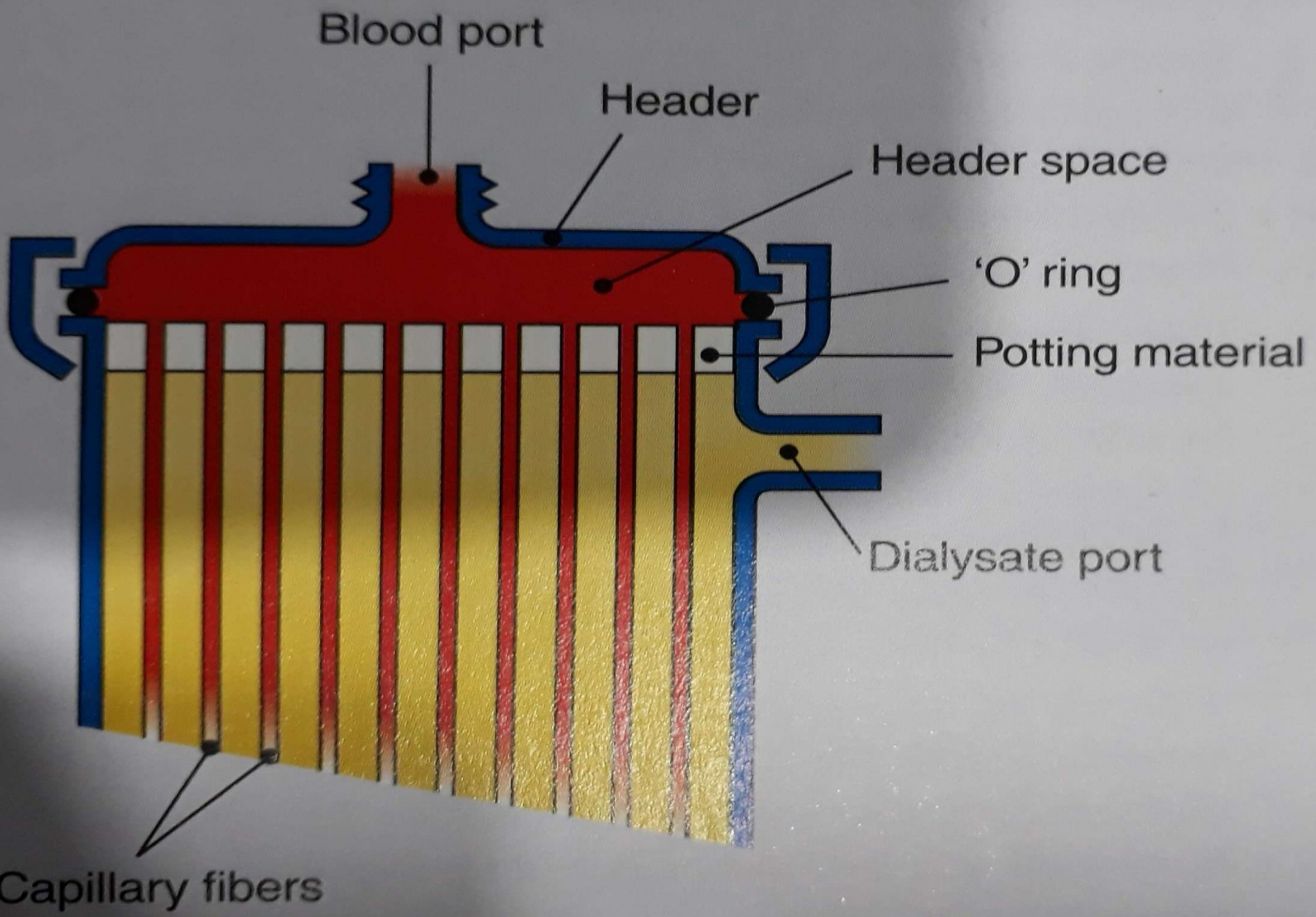
HEMODIALYZER

- Dialyzer is the critical part of the dialysis apparatus where exchange of molecules(dialysis process) occurs. It contain semipermeable membrane, one side blood & other side Dialysate flows.
- The membrane consists of either thousands of capillary fibers (Hollow fiber dialyzer) or Sheets are arranged in parallel plates(Parallel plate dialyzer).
- The Hollow fibers dialyzers are most frequently used.


Blood Inlet
Header
Tube sheet
Dialysate Outlet
Fibers
Jacket
Dialysate Inlet
Blood Outlet


Blood enters the dialyzer from your body.
Dialysate is a special fluid that takes waste from the blood.
A membrane keeps blood and dialysate from mixing, but lets waste pass through.
Waste moves through the membrane from the blood into the dialysate.
Cleansed blood returns to your body.
Used dialysate
Fresh dialysate

Cross Section of a Dialyzer



HEMODIALYZER-COMPONENTS

- The major components are:

1. Blood ports– carry blood in (arterial port) & out (Venous port) of the dialyzer.
2. Headers– from blood ports, blood enters the arterial header space & dialyzed blood enters the Venous header space before Venous port.
3. Potting material –the hollow fibers are anchored to the dialyzer casing with a potting material separating blood from dialsate.
4. Space – bet header & fibers , bet ports & porting material where clotting occurs & poor clearance.
5. Capillary fibers– 10,000 fibers blood flows inside and dialsate outside.

DIALYZER CHARACTERISTICS

- Selection of dialyzer is based on certain performance characteristics.
- Membrane: The material constitutes the membrane are of 3 broad groups.

I. Cellulose Membrane: early material was plant polysaccharide called Cellophane. Later

Cuprophan(cuprammonium cellulose), Saponified cellulose ester and regenerated cellulose. Less expensive but most immunoactivation.(Hydroxyl groups)

II. Substituted Cellulose Membrane: free hydroxyl group bonded to acetate to form cellulose diacetate & triacetate to reduce the complement activation when exposed to blood.

DIALYZER CHARACTERISTICS

III. Synthetic Membrane: These differ from Cellulose membrane as follows:

a. These are more biocompatible
b. Have high hydraulic permeability
c. More expensive.
d. Absorb plasma proteins, Igs & complements.

Common synthetic membranes are Polysulfone(PS), Polyacrylonitrile(PAN),Polycarbonate, Polyamide and Polymethylmethacrylate(PMMA),.

DIALYSIS MEMBRANES

Membrane	Hydr.Perm.	Examples	Biocomp.
Regen. cellulose	Low flux	cuprophane	Poor
Modif. Cellulose	Low/High Flux	Cell.acetate Cell di-acet.	Interm.
Synthetic	High/Low flux	PAN,PS,PA, PC,PMMC	Good

DIALYZER PERFORMANCE

- Dialyzer performance is judged on Solute clearance and UF characteristics.

I. Solute Clearance.

Solute removal characteristics is key measure of dialyzer performance terms as a clearance of urea,creatinine, PO4,uric acid, B2microglobulins & Vit.B12.

Clearance depends on thickness & surface area of the membrane, density , characteristics & size of the pores. Urea clearance is most commonly used measure in calculation of dose of dialysis.

DIALYZER PERFORMANCE

- The clearance data by manufacturer is usually in vitro experiments using water & is always high then blood clearance in vivo. It must not be used for dialysis prescription using urea kinetics.
- Creatinine clearance is 70-95% of urea clearance.
- PO4 & Uric acid clearance generally are not reported but can be used in ↑PO4 Urate (AKI, TLS)
- B12 (MW 1355) has low clearance used for permeability of. Large (middle) molecules
- B2 microblobulins clearance can be used for assessing membrane characteristics.

DIALYZER PERFORMANCE

II. UF Characteristic:

Its used as Kuf term as UF rate (ml/hour/mmHg). Dialyzer with a Kuf of > 8 ml/hour/mmHg should be used with modern volumetric machines.

Surface area & Porosity of the Membrane: Dialyzer clearance is dependent on porosity & total surface area of the dialyzer membrane. The surface area of most dialyzer is 0.8 – 2.1m^2 .

Priming Volume: It is vol. of blood compartment of the dialyzer ranges 50—150ml.

Membrane thickness: Thin membrane are more permeable than thicker membrane But cant withstand to TMP than thicker Membrane.

HIGH –EFFICIENCY/FLUX DIALYZERS

- Dialyzer with high permeability are called High efficiency dialyzers.
- A dialyzer with a Kuf of 10-19 ml/mmHg/hour or a KoA urea of 450-600 ml/minute is considered

  High-efficiency Dialyzers.
- Dialyzer with a Kuf >20ml/mmHg/hour or with a KoA urea > 600 ml/minute are called High-flux dialyzers.

DIALYZER STERILIZATION

- The dialyzer sterilizations techniques are important.
- The most common method is ethylene oxide(Eto).
- Eto removal is very important prior to HD as it caused anaphylactic reaction. Eto-sensitive patients alternate methods(eg gamma radiation or steam autoclaving)should be used.

RE-USE OF DIALYZERS

- With the use of more expensive high-flux dialyzers cost saving is the main factor for Re-use.
- The technique involves rinsing with clean water or by cleansing agents i-e sodium hypochlorite(bleach)

  H_2O_2,or peracetic acid. After thorough cleansing dialyzer is sterilized : Formaldehyde or Glutarraldehyde can be used & heat. (Renatron).

Safety checks before Re-use are:

- Dialyzers tested chemically to ensure no reagent left
- Membrane patency is checked - use of pressure test
- Dialyzer efficacy is tested by measuring fiber bundle volume. FBV > 80-85% of the baseline –Adequate.

DIALYSIS CIRCUIT

- The major components of dialysis Circuit are:

1- Dialysate Concentrates.

2- Dialysate Delivery System.

1- Dialysate Concentrates:

The Dialysate usually comes in the form of concentrate i-e mixed with an appropriate vol. of water to make a solution that is pumped via a Dialyzer.

Two type of concentrates based on main basic anion.

a. Acetate concentrate.

The basic anion is sodium acetate. With the use of more efficient dialyzer in mid70s problem with acetate toxicity .

Now limited use.

DIALYSIS CIRCUIT

b. Bicarbonate Concentrate:

The main basic anion is Bicarbonate for Dialysate concentrate is made in two parts.

Part A, (acid concentrate) contains all the electrolytes & glucose.

Part B, contains sNaHCO3 in concentrated solution.

Appropriate proportions of A &B are pumped into two proportioning system where mixed with water to final Dialysate concentration.

The HCO3 sol. is 20 times concentrated, one part diluted with

19 parts of water. Acid concent. 34 or 44 times concentrated.

Component	Concentration mmol/L
Na	140
K	2
Ca	1.25 (5 mg/dl)
Mg	0.5 (1.2 mg/dl)
Acetate	3.0
Chloride	108
Bicarbonate	35
Glucose	5.6 (100 mg/dl)

DIALYSIS SOLUTION

Composition of Hemodialysate

Constituent	Concentration Range in Final Dialysate (mEq/l)		
	Acetate Based	Bicarbonate Based	Most Common Concentration
Sodium	135–145	135–145	137.5
Chloride	100–116	100–116	106
Potassium	0–4	0–4	2
Calcium	2.5–3.5	2.5–3.5	3
Magnesium	0.5–1.5	0.5–1.5	0.75
Acetate	35–38	2–4	4
Bicarbonate	—	35–38	37.5
Dextrose*	0—200*	0–200*	200*

Table 2.1. *mg/dl.

DIALYSATE DELIVERY SYSTEM

- This system blends & provides Dialysate to the dialyzer, monitor Dialysate quality, and controls & monitor UF from the patient. It can be divided into four major components.

1.Water Preparation System. Treated water delivered De-aerated(subjecting heated water to a negative Pressure Via a Pump) .Water then delivered to proportioning system.

2. Proportioning System. Here part A & B of the dialysate concentrate are mixed(at appropriate ratio) with treated water to form final A & B dialysate to be mixed to final dialysate & pumped to dialyzer, if the Conductivity is in accepted range otherwise diverted to bypass loop.

DIALYSATE DELIVERY SYSTEM

3. UF Controller: In modern volumetric control machines

fresh dialysate passes via a volume-measuring device before

going to dialyzer, & spent dialysate from dialyzer (along with

UF Vol.) is passed via this device again. By comparing 2 vol.

machine can track UF vol. accurately.

Two type of UF Controller design exists.

Balancing chamber, a diaphragm fluctuation quantify the UF

Volume-separates dialysate inflow & outflow.

The Gear System design , free flywheels with gears through

which dialysate inflow & outflow passed .No. of rotations give UF Vol. measurements. An integral part of UF controller is dialysate pressure controller(TMP).

DIALYSATE DELIVERY SYSTEM

TMP is the pressure on dialyzer side(the sum of pressure on

the blood & dialsate sides). And it controls the UF rate.

The volume to be ultrafiltered during each treatment is

determined by patient weight.

The machine changes & controls the dialysate pressure

appropriately(for blood circuit pressure & UF Volume).

The usual range of dialysate pressure in modern machines is

-400 to + 350 mmHg.

DIALYSATE DELIVERY SYSTEM

4. Monitors & Detectors: For safety several monitor & detectors are used in DD system.

a. Conductivity monitor: Appropriate mixing of concentrate with water is monitored by conductivity. This monitor check electrolytes concentration in the final dialysate, any malfunction results in abnormal proportioning –fatal for the patient. Any deviation from the narrow range causes alarm-disruption of HD.

b. Temperature Monitor: optimal temperature of dialysate for dialysis is 36-42C. Dialysis below 36C , patient will feel cold & uncomforting while above 42C is associated with severe hemolysis & cardiopulmonary arrest. Dialysate temp. is monitored & a Thermostat controls the water heater. Any increase in temp. out of range trigger alarm & HD stopped.

DIALYSATE DELIVERY SYSTEM

c. Blood leaks detector: Blood leak sensors are placed on the dialysate outflow line. These are usually flow-through photo-optical or blue frequency spectrum sensors.

d. pH sensors: Some machines has pH electrode as a part of proportioning system. It is used to prevent any mistake in connecting the appropriate concentrate to the machine. (eg B concentrate not being connected).

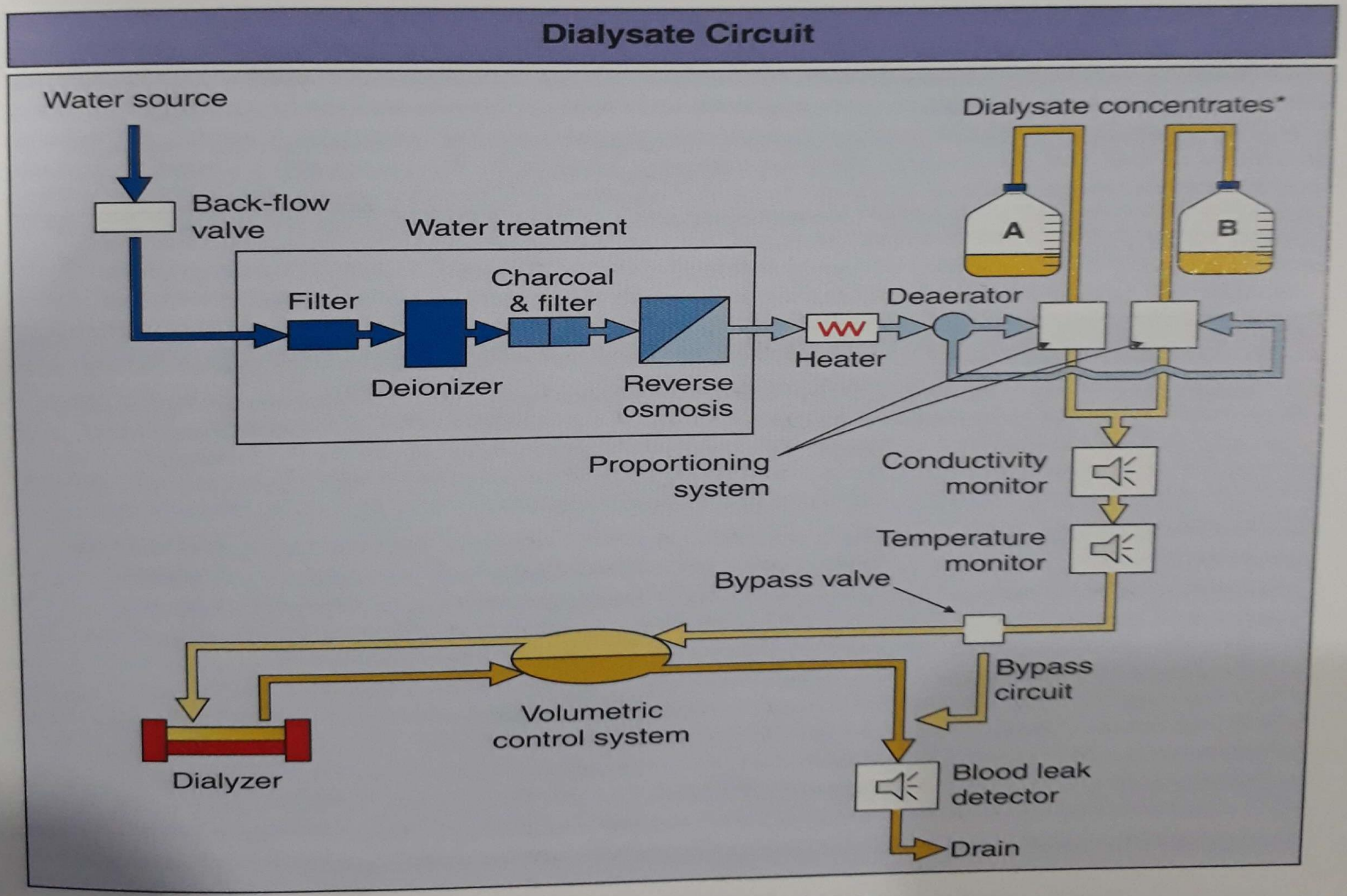


Figure 2.5. *Only one concentrate is used with acetate dialysate.

DIALYSIS WATER

- A large volume (>100 liter per treatment) is used to make dialysate
- from the concentrate.
- Dialyzer membrane acts as a filter & prevents bacteria & endotoxins from crossing into the blood, so dialysate & water are not to be sterile.
- The bacteria colony count is in the water should be <200/ml.
- Small molecules may enter the blood via dialysate water, need to be removed, injurious to patients.
- Contaminants like Aluminum(bone & brain problems , anemia), and Chloramines (H.Anemia).
- The Association for the Advancement of Medical Instrumentation (AAMI) has recommended minimum standard for the water used in dialysate.

TOXIC WATER CONTAMINANTS

CONTAMINANT	SOURCE	ADVERSE EVENT
ALUMINUM	MUNICIPAL WATER	ENCEPHALOPATHY, BONE DISEASE, ANEMIA
CHLORAMINES	MUNICIPAL WATER	HEMOLYSIS
FLUORIDE	MUNICIPAL WATER	FATAL ARRHYTHMIA, BONE DISEASE (?)
CYANOTOXIN	SOURCE WATER	LIVER FAILURE
NITRATES	SOURCE WATER	ANEMIA
ENDOTOXIN	DIALYSIS UNIT	PYROGENIC REACTIONS, CHRONIC INFLAMMATION
COPPER	DIALYSIS UNIT	HEMOLYSIS, NAUSEA, VOMITING
ZINC	DIALYSIS UNIT	HEMOLYSIS, NAUSEA, VOMITING
CALCIUM, MAGNESIUM	SOURCE WATER, MUNICIPAL WATER	NAUSEA, VOMITING

AAMI WATER QUALITY STANDARDS - 2000 (DRAFT)

SUBSTANCES IN DIALYSATE	
CALCIUM	2
MAGNESIUM	4
SODIUM	70
POTASSIUM	8
TOXIC SUBSTANCES (SDWA)	
ANTIMONY	*0.006*
ARSENIC	0.005
BERYLLIUM	*0.0004*
BARIUM	0.01
CADMIUM	0.001
CHROMIUM	0.014
CYANIDE	*0.02*
LEAD	0.005
MERCURY	0.0002
SELENIUM	0.09
SILVER	0.005
THALIUM	*0.002*

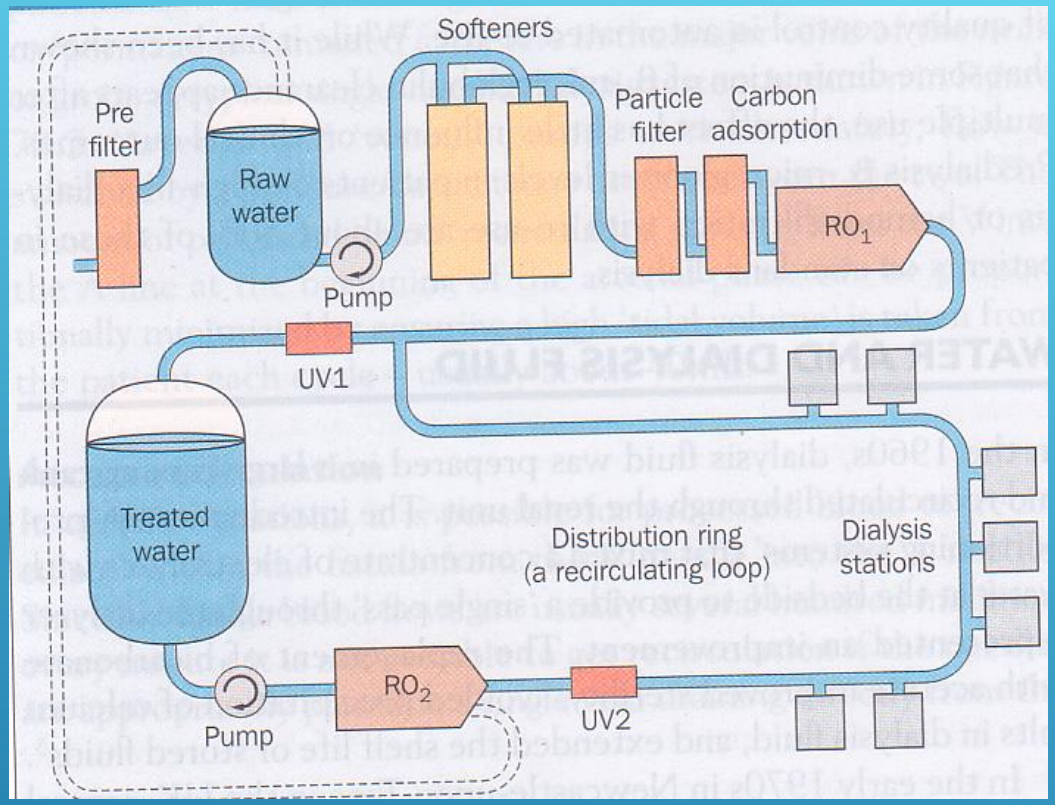
SUBSTANCES TOXIC IN DIALYSIS	
ALUMINUM	0.01
CHLORAMINES	0.10
FREE CHLORINE	0.5
COPPER	0.10
FLUORIDE	0.20
NITRATE (as N)	2.0
SULFATE	100
ZINC	0.10

MICROBIOLOGICAL CONTAMINANTS	
BACTERIA	200
ACTION LEVEL	*50*
ENDOTOXIN	*2*
ACTION LEVEL	*1*

CHEMICAL CONCENTRATIONS IN mg/L, BACTERIA CFU/ml, ENDOTOXIN EU/ml

WATER TREATMENT SYSTEM

- The most common method for purifying dialysis water is Reverse Osmosis(RO) where water is pressured across a tight membrane(with pores small enough to remove urea, Na,&Cl)
- The process removes > 90% of impurities . Activated charcoal & ion exchange resins(deionizers) to remove Inorganic charged ions & non-ionic contaminants.
- With high flux dialyzer there is concern abt. Contaminated dialysate passing in blood by reverse UF. The B concentrate ($NaHCO_3$) can be major source of bacterial contamination.
- That's why High Flux dialyzer is inserted in dialysate flow path to filter & remove any contaminant to produce ultraclean dialysate.



WATER TREATMENT SYSTEM FOR HEMODIALYSIS

ANTICOAGULATION

- Contact with a foreign surface leads to clotting of blood due to activation of intrinsic pathway & platelets.
- Prevention of clotting is essential for effective treatment which enables the free passage of blood via dialyzer & to prevent clotting of dialyzer fibers(reduce the surface area hence reduce dialysis efficiency).
- HD patients are at increased risk of bleeding while clotting of extra-corporeal system & vascular access is common too. different sensitivity to heparin in different patient (even same patient at different time).

HEPARIN ANTICOAGULATION

- The most common anticoagulation in HD continues to be Heparin. Two main types of heparinazation techniques,

I. **Systemic Standard Heparinazation:** most commonly used in stable chronic HD patients & use Heparin bolus to increase the ACT to 200-250 seconds (normal 90-140 sec.). Followed by continuous infusion of heparin(500-2000 units/hour) to maintain the ACT in range.
To prevent excessive bleeding, heparin must be stopped 30-60 minutes before termination of HD.

II. Low Molecular Weight Heparin: LMWH small fraction(4-6 kd). it causes minimal inhibition of thrombin factor IX or X , PT & partial thromboplastin are not markedly elevated. It is used as a single bolus dose at the start of HD. LMWH more expensive than heparin. A 40 mg loading dose & 10-40mg/hour maintenance dose is used.

REGIONAL CITRATE ANTICOAGULATION

- Citrate is one of the best & longest used alternative to heparin. It prevents clotting by binding with calcium necessary for clotting cascade. EC system anticoagulation. Citrate is infused at arterial segment of BT, calcium removed from dialysate, calcium infused in Venous segment-- patient. It reduces the risk of bleeding. Trisodium citrate solution is infused (102mmole/l) at 2-6% of the blood flow rate, higher for the 1st few minutes then decreased. Infusion of calcium should be started at the same time to prevent fatal cardiac arrhythmias . CaCl solution (3-5% solution & infused at a rate of 0.5ml/min into venous segment.

REGIONAL CITRATE ANTICOAGULATION

- Citrate anticoagulation reduces the risk of bleeding & keeps

dialysis free of clots. Disadvantages are ,

More expensive than heparin

More fluctuation in serum calcium levels

It causes hypernatremia & alkalosis to prevent this citrate

solution is made in aqueous dextrose solution & dialysate

bicarbonate conc. should be reduced to 25 mEq/l.

Dialysate Citrate: novel method to use citrate inn dialysate. (DRYdialysate). It is associated with significant increase in

delivered dose of HD. It keeps the dialyzer fibers & pores

open, this increasing solute transport.

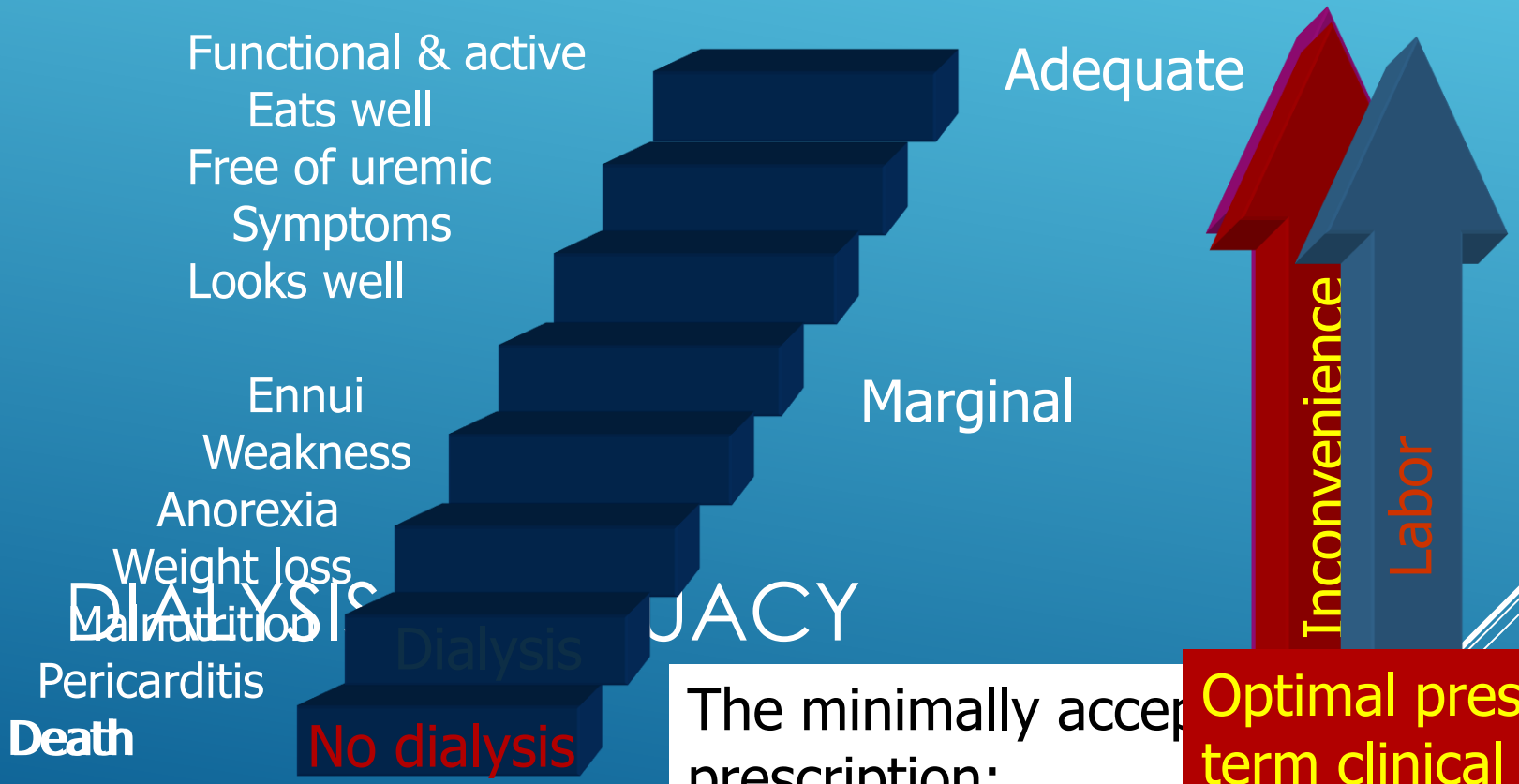
ALTERNATIVE ANTICOAGULATION

I. **Recombinant Hirudin**: It inhibits both thrombin induced & platelets-induced clotting but it doesn't not platelets aggregation.(unlike Heparin). It is administered as a single bolus dose at start of HD. It prolong half life increase the risk of bleeding. More expensive

II. Prostacyclin & other Prostanoids: These are potent platelets inhibitors. Prostacyclin has a very short half-life . It is used as constant infusion of about 4ng/kg/min. Expensive & vasodilatation hypotension limits its use.

NO ANTICOAGULATION

- Patients with AKI & high risk of bleeding HD can be done with no anticoagulation. The dialyzer & tubing set are pre soaked with 2000-7000 units of heparin for >30 min. Rinse all heparin before connecting to the patient.
- Alternatively, periodic (every 30 min.) rinsing of blood Circuit with saline minimizes the risk of clotting.
- Use of Erythropoietin(Epo) to prevent anemia is associated with increase clotting & needs better anti-coagulation.
- The High-Flux dialyzer & its Re-use need good anti coagulation.
- Better anti-coagulation avoid under dialysis(due to fibers clotting) or access thrombosis.



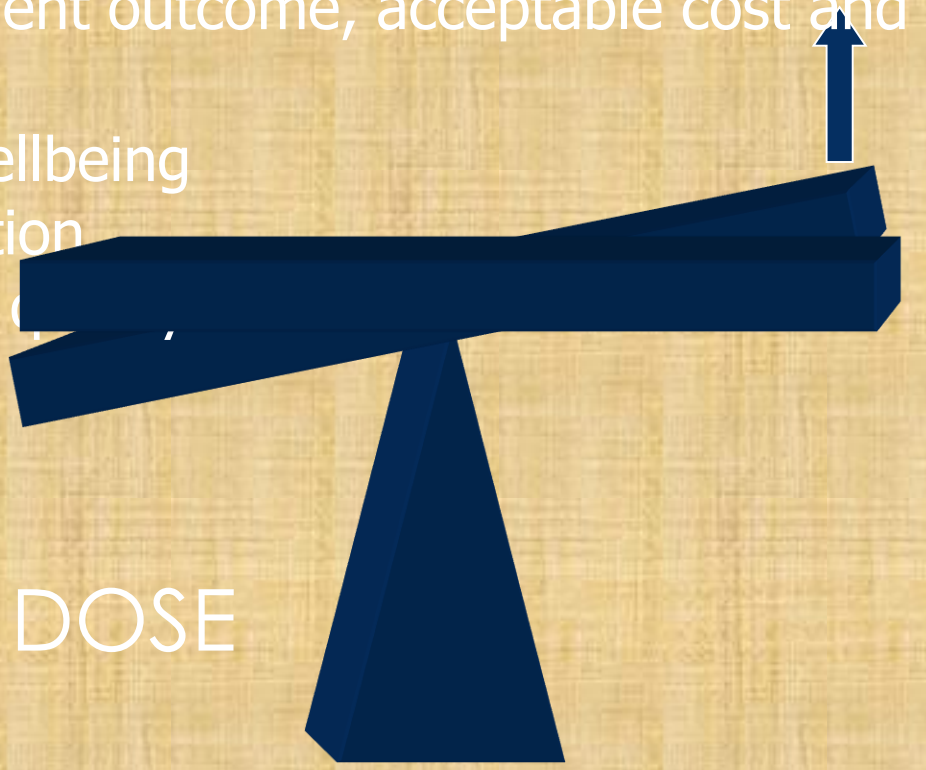
The minimally accep
prescription;
avoids the more
ensures accepta

Optimal prescription p
term clinical outcome
lower morbidit
mortality,

Acceptable patient outcome, acceptable cost and inconvenience

Patient wellbeing
Rehabiltation
Improved

Cost
Labor
Inconvenience



DIALYSIS DOSE

WHAT IS ADEQUATE DIALYSIS?

- That treatment by which all the symptoms and signs of uremia are eradicated and the patient is fully rehabilitated.
- Symptoms and signs due to retention of nitrogenous waste products.

CATHETER USED FOR DIALYSIS

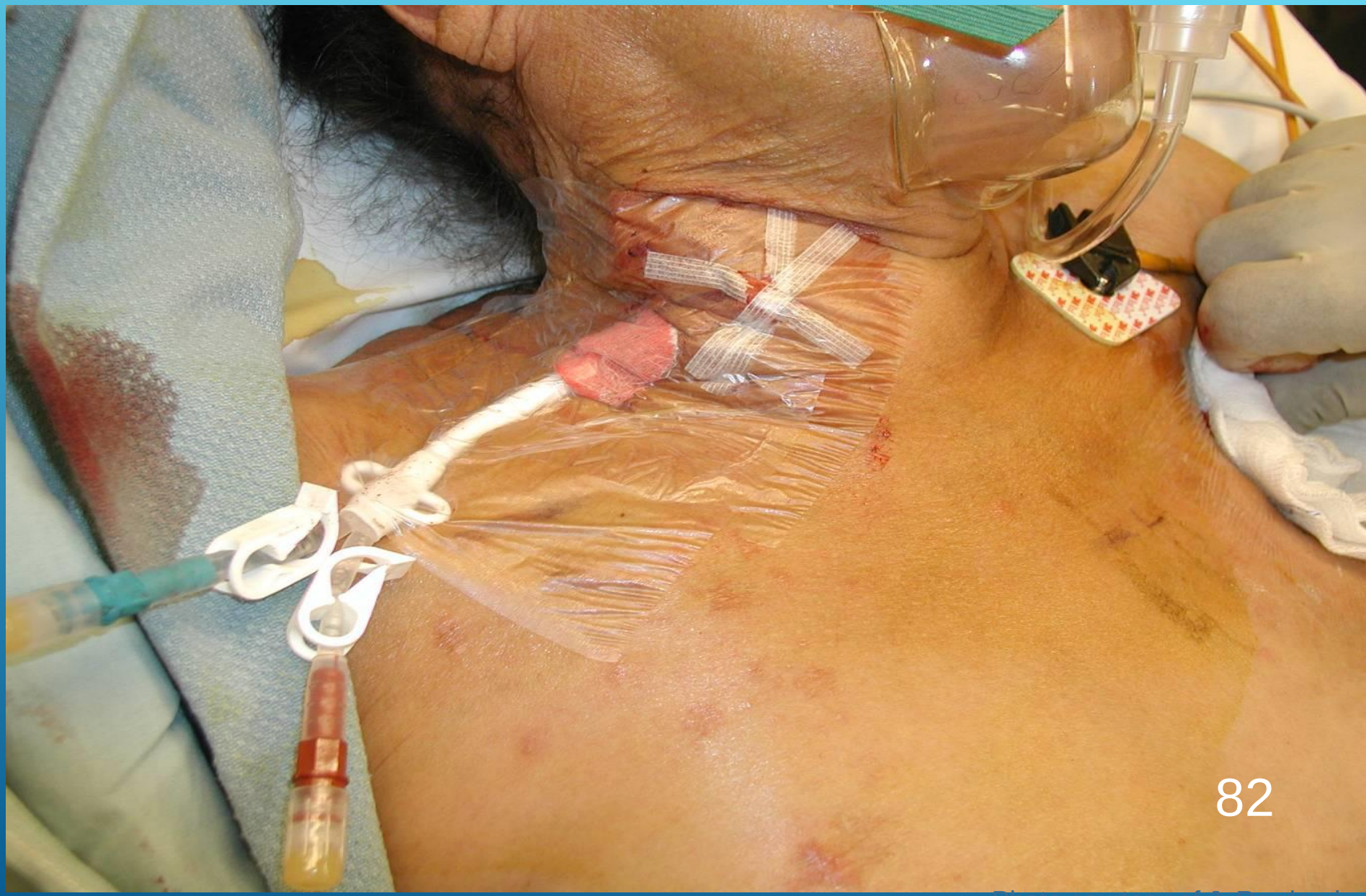


Photo courtesy of J. Rowland

ARTERIO-VENOUS GRAFT

Photo courtesy of J. Rowland

MATURE ARTERIO-VENOUS FISTULA

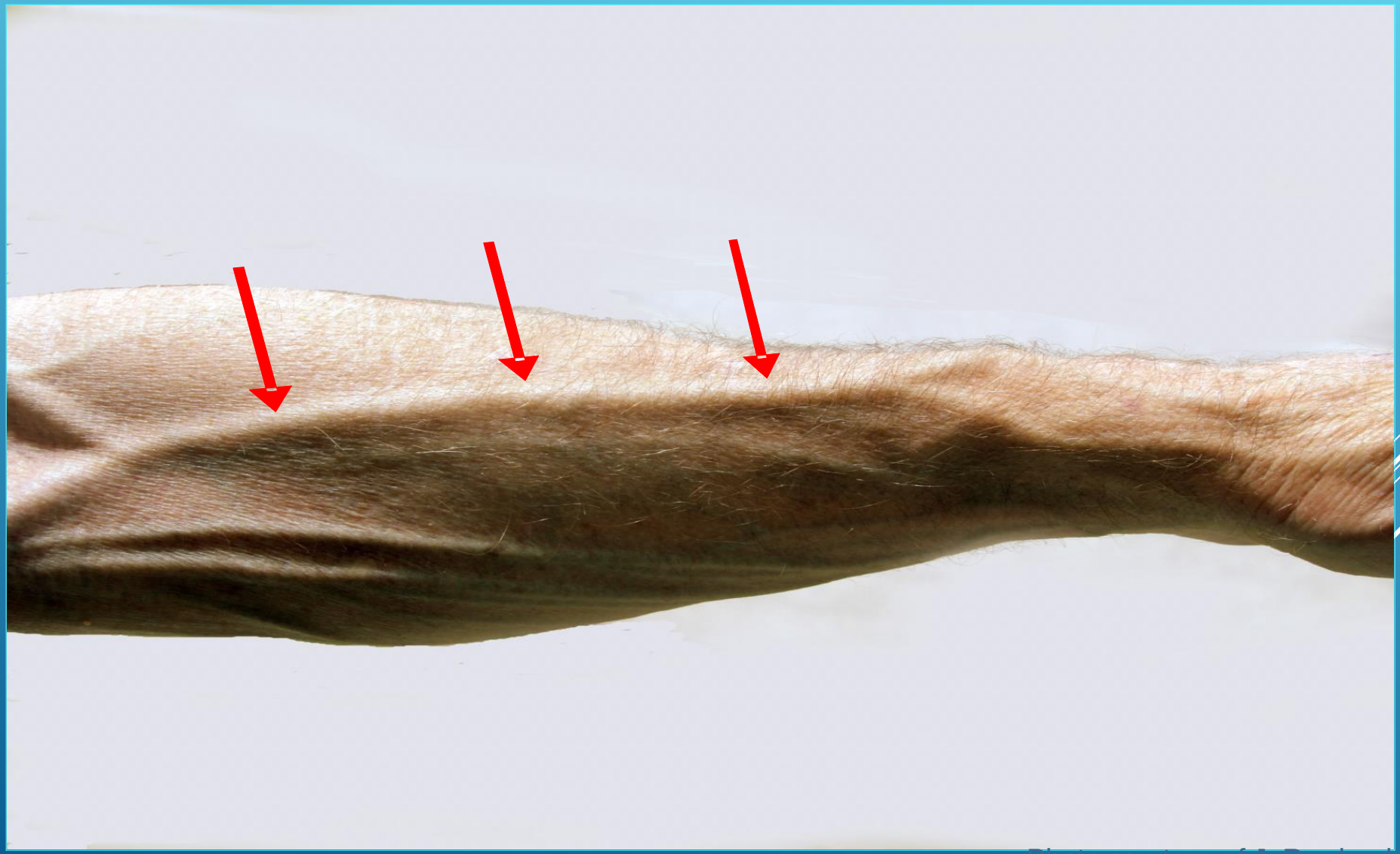


Photo courtesy of J. Rowland

CAPD: ADVANTAGES

- Better preservation of residual renal function
- Less EPO requirement
- Better control of hypertension
- Less risk of viral hepatitis
- Extends dialysis to children and elderly patients
- Diabetics with vascular access problems are one of the largest group undergoing CAPD
- Home based, ambulatory treatment that works within the body.

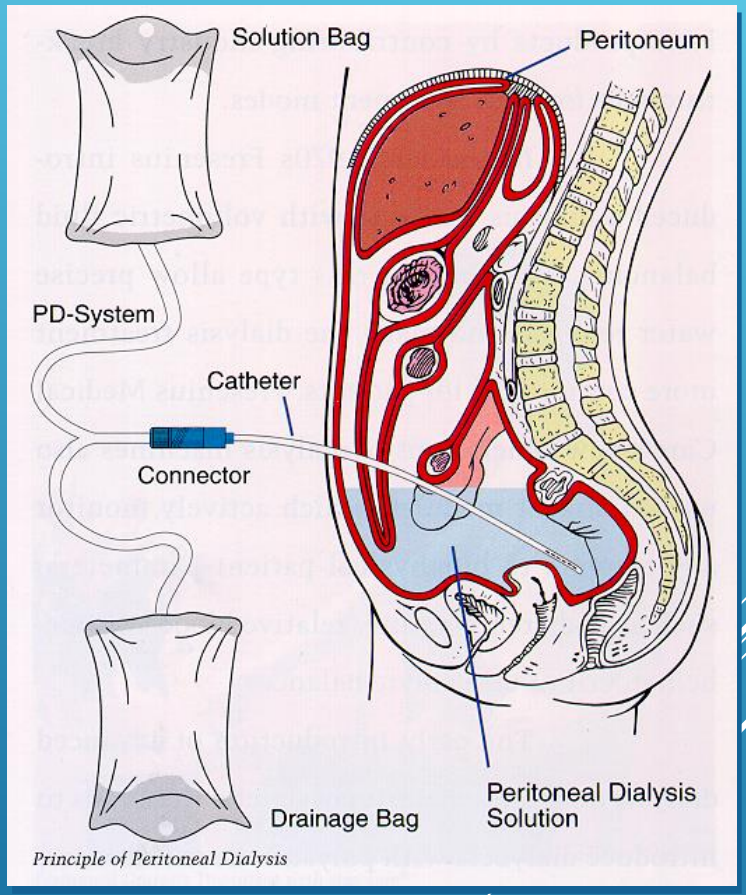
PERITONEAL MEMBANE AS A FILTER

- Peritoneal membrane is a biological serosal membrane equal to body surface area
- It has visceral & parietal layers
- Peritoneal blood flow rate is 50-100 mls/min
- Transport depends on surface area of the capillaries

What is Peritoneal Dialysis ?

INTRACORPOREAL DIALYSIS:

- **Heart as blood pump**
- **Peritoneum as dialyzer**
- **No machine**
- **No anticoagulation**



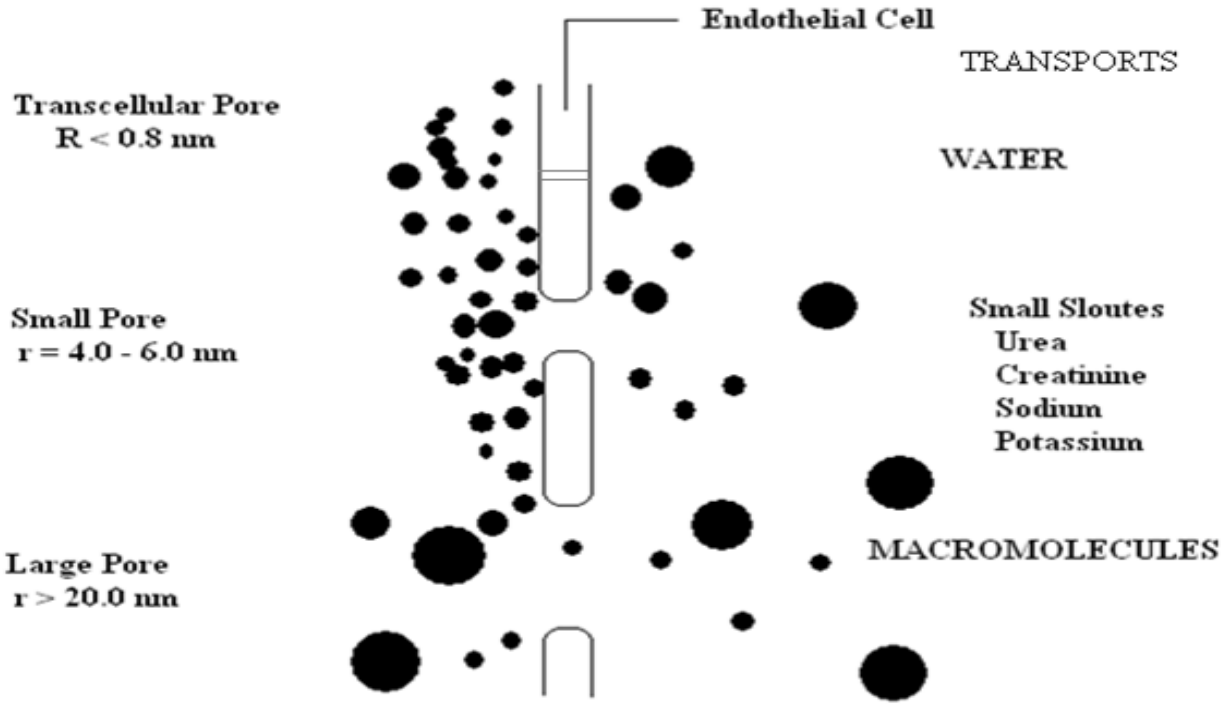
PERITONEAL FILTER

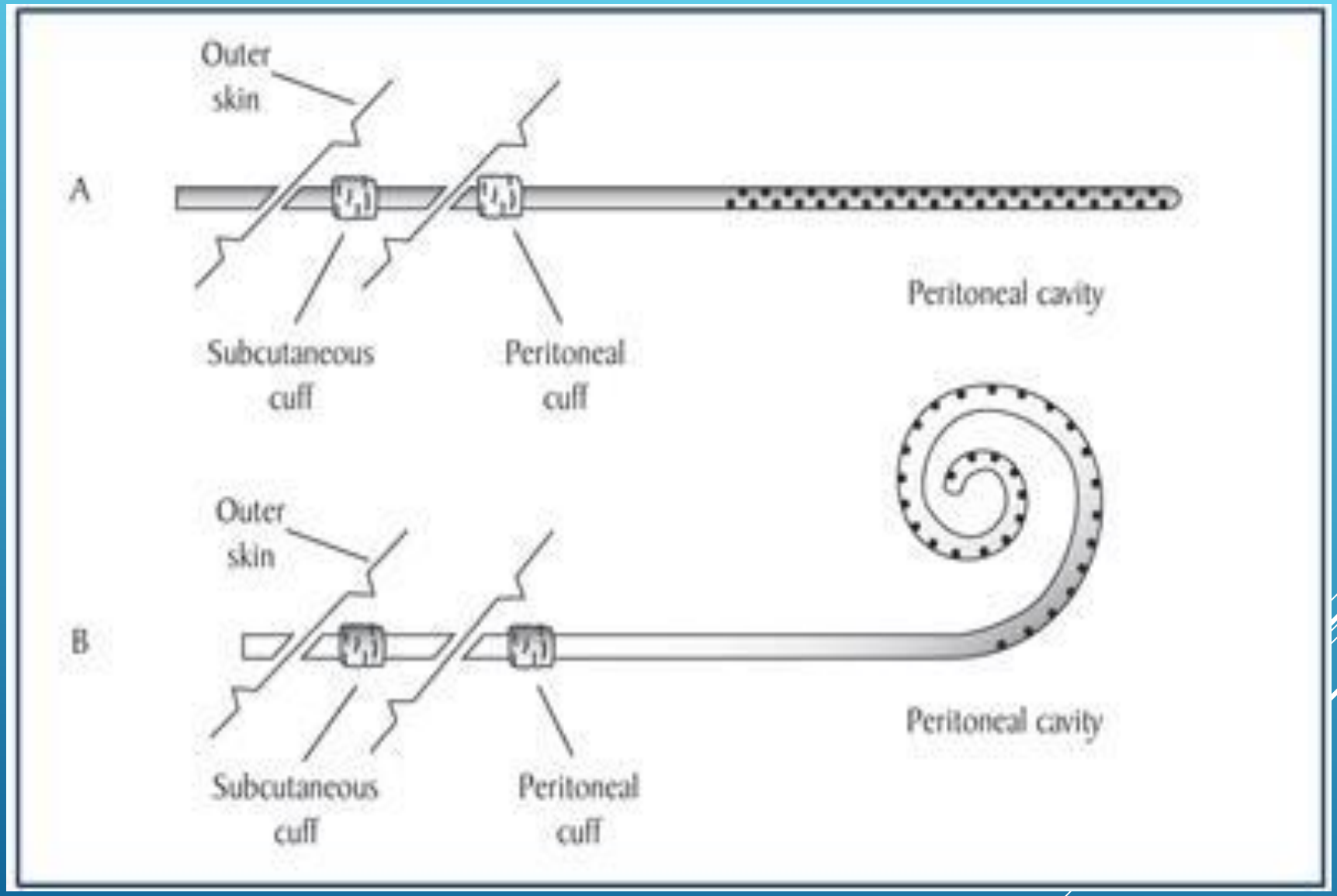
- Peritoneal membrane has mesothelium, interstitium and capillary basement membrane
- Peritoneal endothelium is the critical barrier
- Peritoneal clearance is the net result:
  - Diffusion+Utrafiltration- Absorption.

PERITONEAL TRANSPORT

- Diffusion
  - Conc.grad
  - Perit.memb.surf.area
  - Memb. Resistance
  - Mol.wt. of solute
- Ultrafiltration
  - Conc.gradient for osmotic agent
  - Effective Surf.area
  - Hydraulic conductance
  - Reflection coeff.for osmotic agent
  - Hydrostatic pressure grad.
  - sieving
- Absorption

Three Pore Model




A
Outer skin
Subcutaneous cuff
Peritoneal cuff
Peritoneal cavity
B
Outer skin
Subcutaneous cuff
Peritoneal cuff
Peritoneal cavity

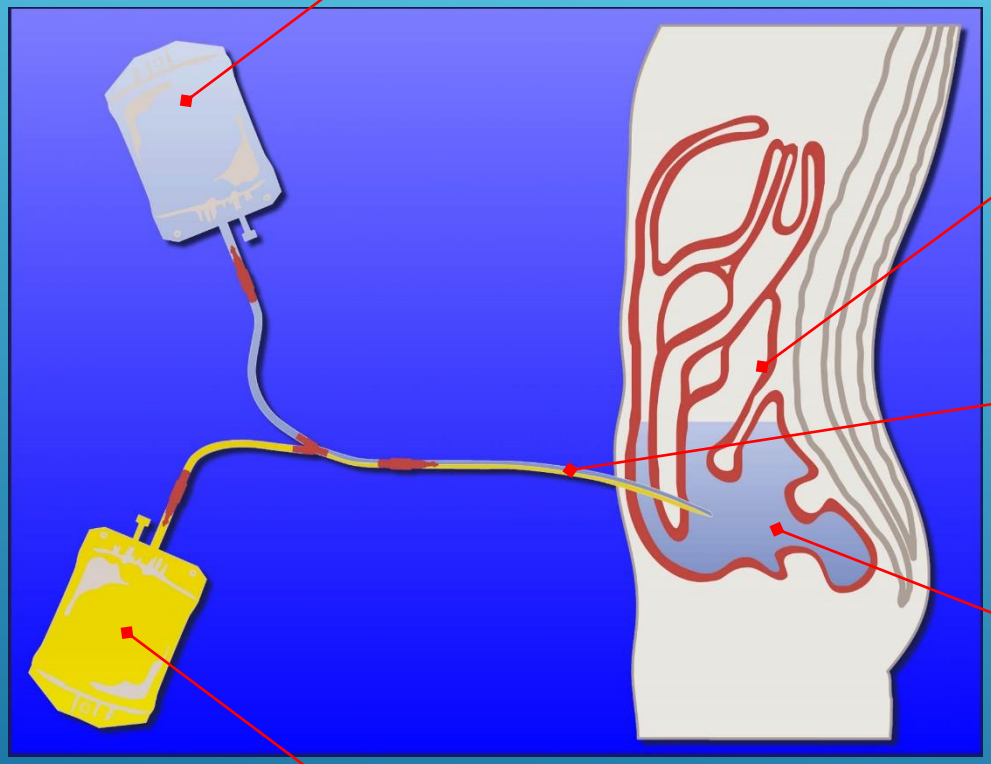
PERITONEAL DIALYSIS

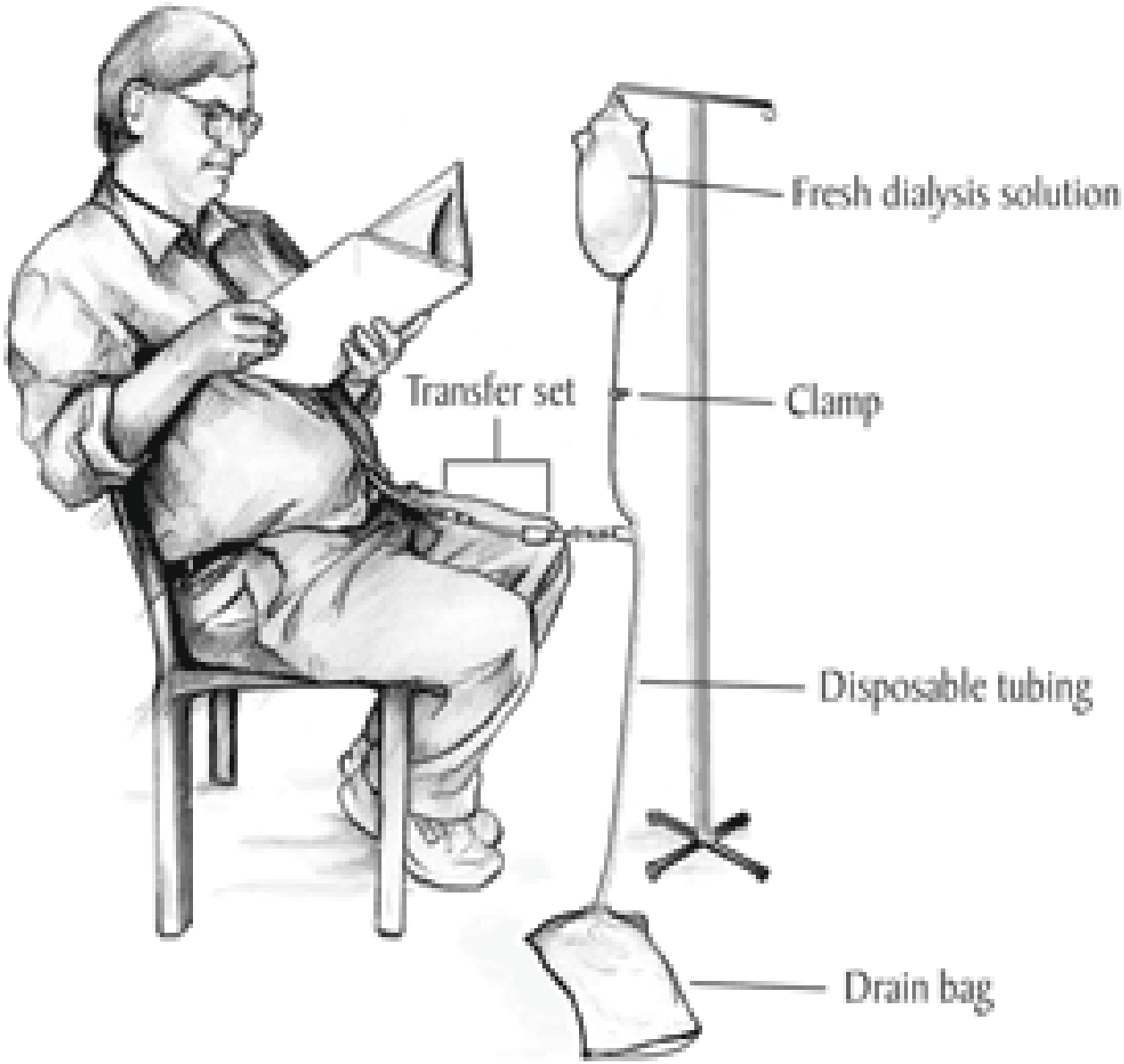
HOW IS PERITONEAL DIALYSIS DONE?

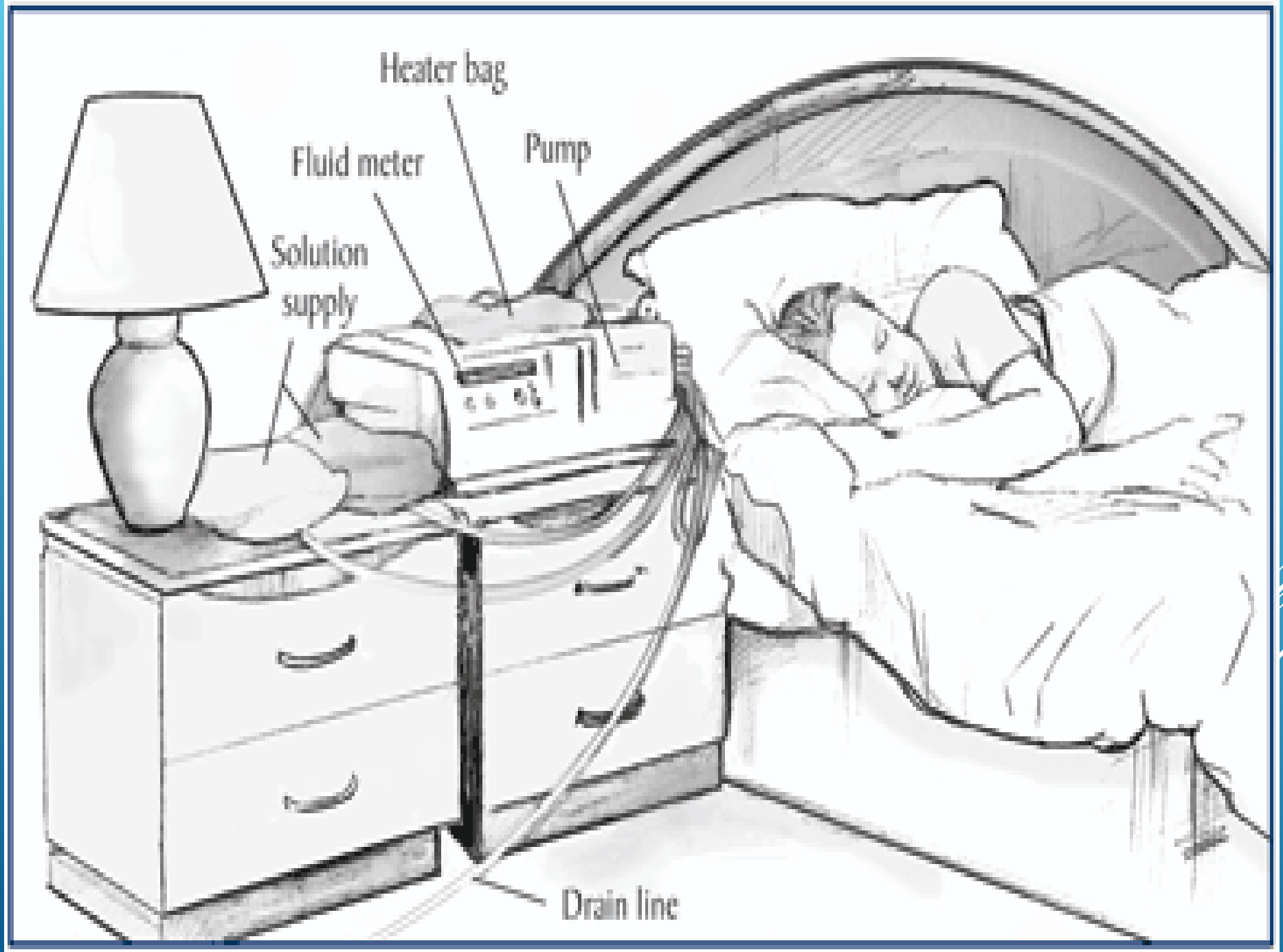
Peritoneal dialysis is done by filling specially composed peritoneal dialysis solution into the abdominal cavity.

The solute transfer between blood and the solution happens by diffusion.

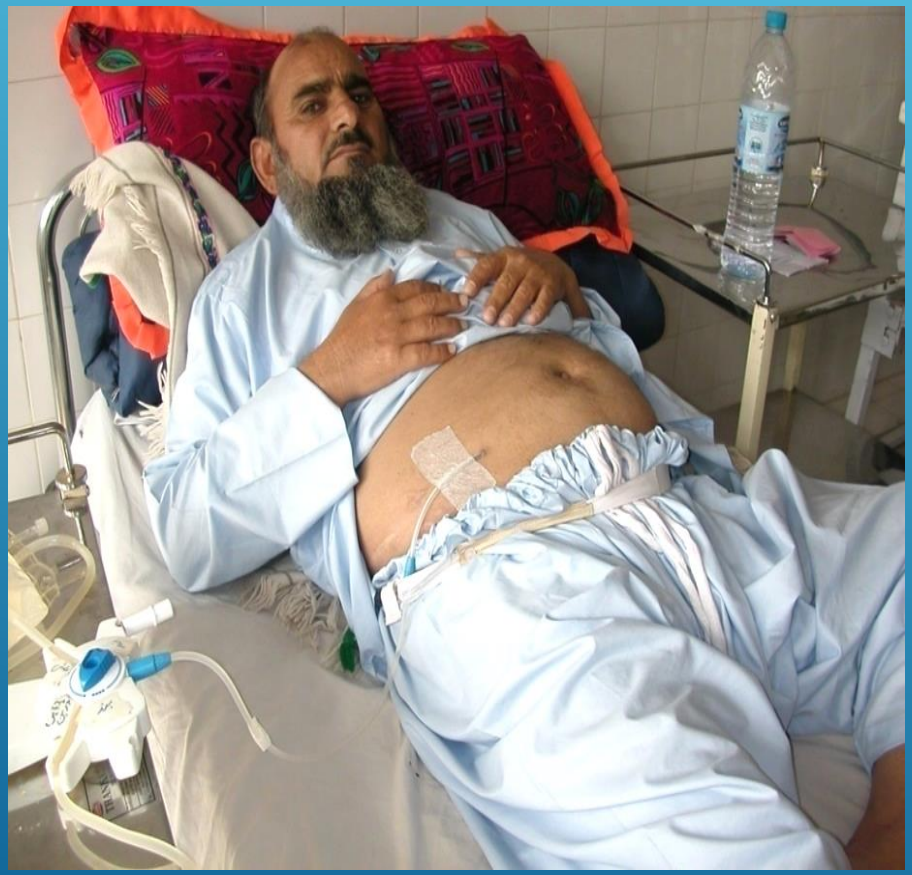
The water removal from the patient is an osmotic process.



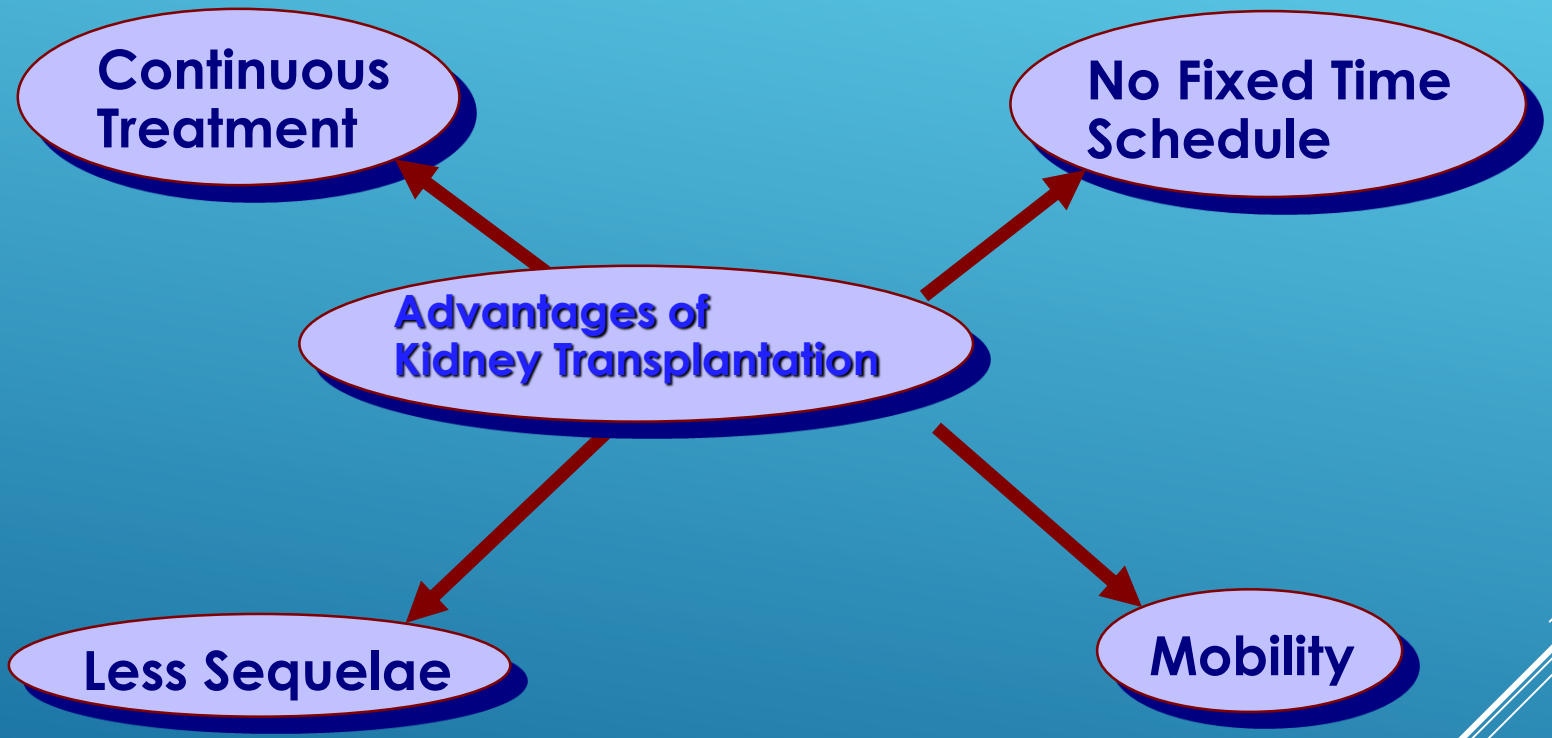

Fresh dialysis solution
Transfer set
Clamp
Disposable tubing
Drain bag


Heater bag
Fluid meter
Pump
Solution supply
Drain line

CAPD TRAINING



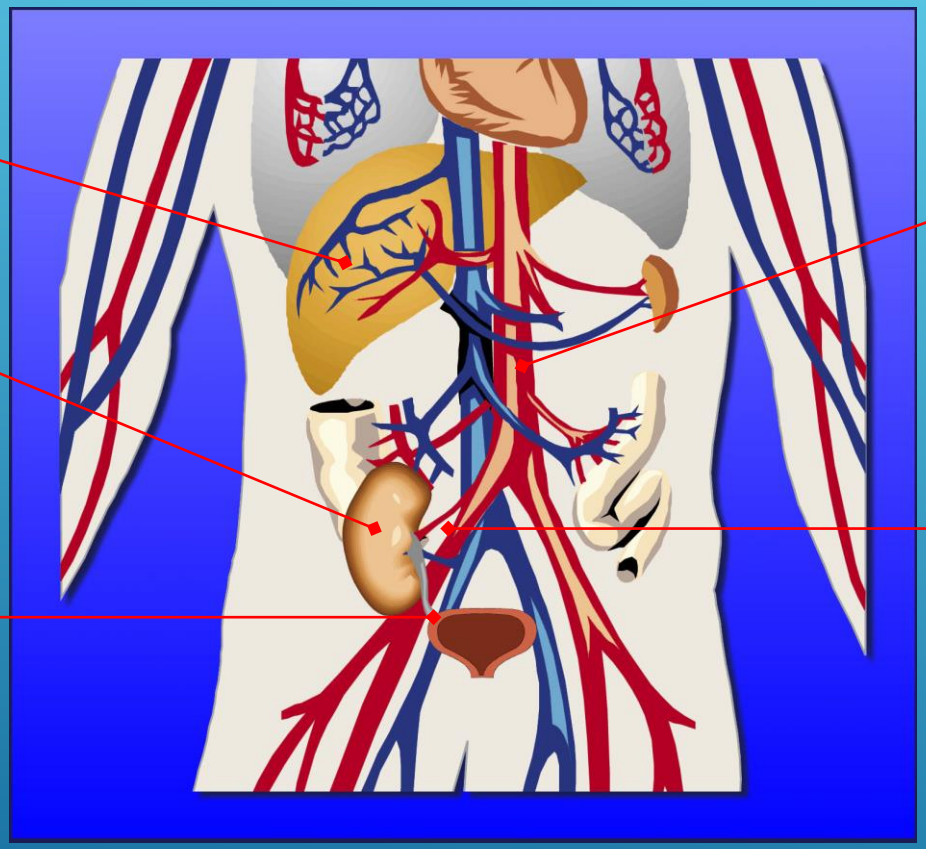
ADVANTAGES OF KIDNEY TRANSPLANTATION



Healthy Kidney | Diseased Kidney | Physical Basis | Renal Replacement

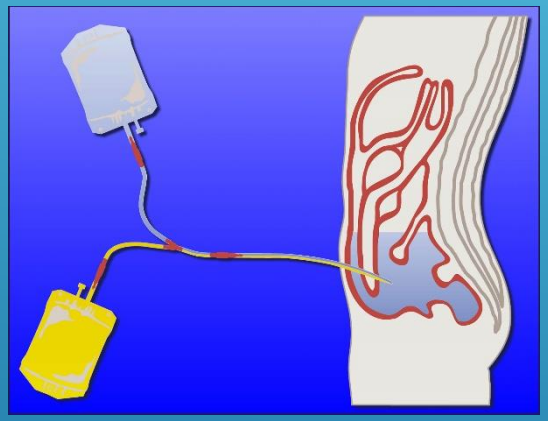
KIDNEY TRANSPLANTATION

LOCATION OF A KIDNEY TRANSPLANT

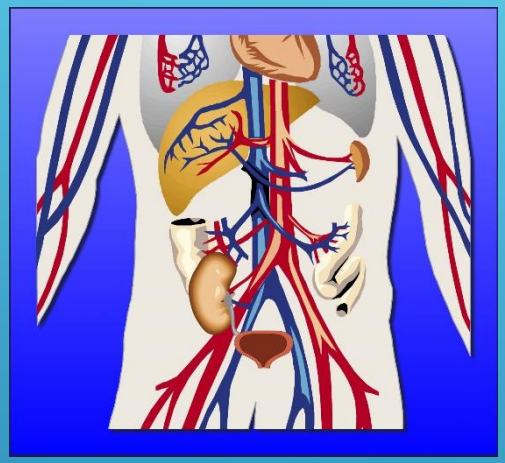


Healthy Kidney | Diseased Kidney | Physical Basis | Renal Replacement

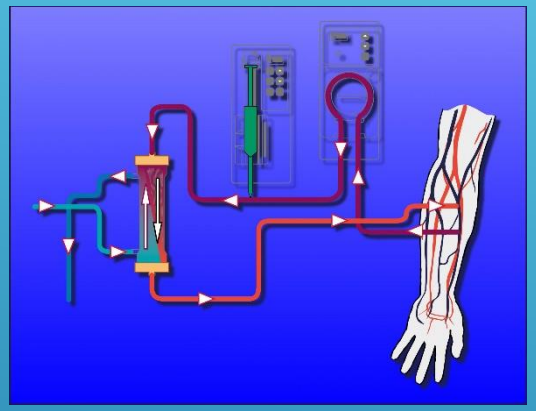
WHICH MODE OF RENAL REPLACEMENT THERAPY?



Peritoneal Dialysis

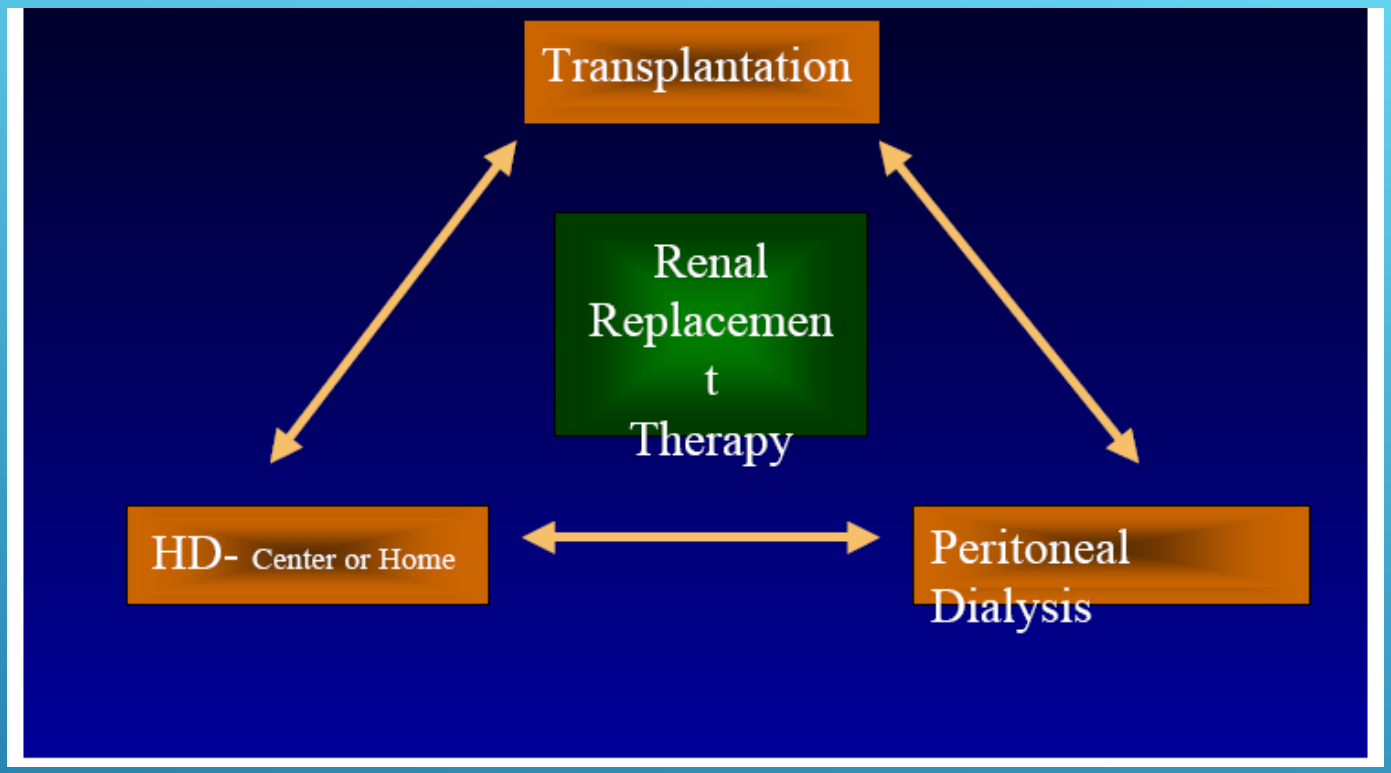


Kidney Transplantation



Hemodialysis

Each mode has its advantages and disadvantages.
The selection is made in a discussion between patient and physician.



INTEGRATED APPROACH