SNS COLLEGE OF TECHNOLOGY

Coimbatore-35
An Autonomous Institution

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Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai

DEPARTMENT OF BIOMEDICAL ENGINEERING

19BMB302 - BIOMEDICAL SIGNAL PROCESSING

III YEAR/ V SEMESTER

Unit IV : BIOSIGNALS AND THEIR CHARACTERISTICS

- Source of Bioelectric potential
- Resting and action potential
- Propagation of action potentials in nerves
- Characteristics of biomedical signals
- The ECG-Cardiac electrophysiology
- Relation of ECG components to cardiac events
- Clinical applications

DIALYSIS

BASIC FUNCTION OF KIDNEY

- **Removal of waste products from the blood plasma.**
- **Regulation of the composition of blood plasma**

- **The greater part of the non-volatile waste products are excreted through the kidneys.**
- **Nitrogenous breakdown products, formed in the combustion of proteins, are excreted only through the kidneys.**
- **If neither kidney is functioning, the nitrogenous substances (e.g. urea) accumulate in the body and uremia (urine poisoning of blood) occur.**

Roles of the kidney

- Excretion
- Homeostasis
- Osmoregulation
- Regulation of salts in the body
- Regulation of pH
- Production of a hormone (EPO)

Changes in body fluids in Renal Failure

- **Uremia**- Urine in blood- Waste products reach high concentration in the blood and affect the physiology.
- **Proteinuria**- Urine contains proteins and albumin (albuminuria).
- Function of nephrons decreases leads to the decrease in clearance of waste products – urea, creatinine, other metabolic wastes.

Renal Failure (Dialysis)

- Renal failure – leads to acidosis – leads to increase in potassium in the ECF and this will affect heart function.
- Also the amount of fluid increases

Two Types

- **Chronic** – due to nephritis (inflammation of kidneys, obstruction due kidney stones , tumours, disturbed renal circulation)
- **Acute-** Poisoning by organic and inorganic chemicals

Indications for Dialysis

- Acidosis
- Electrolytes
- Ingestions
- Overload
- Uremia

DIALYSIS

Two Types

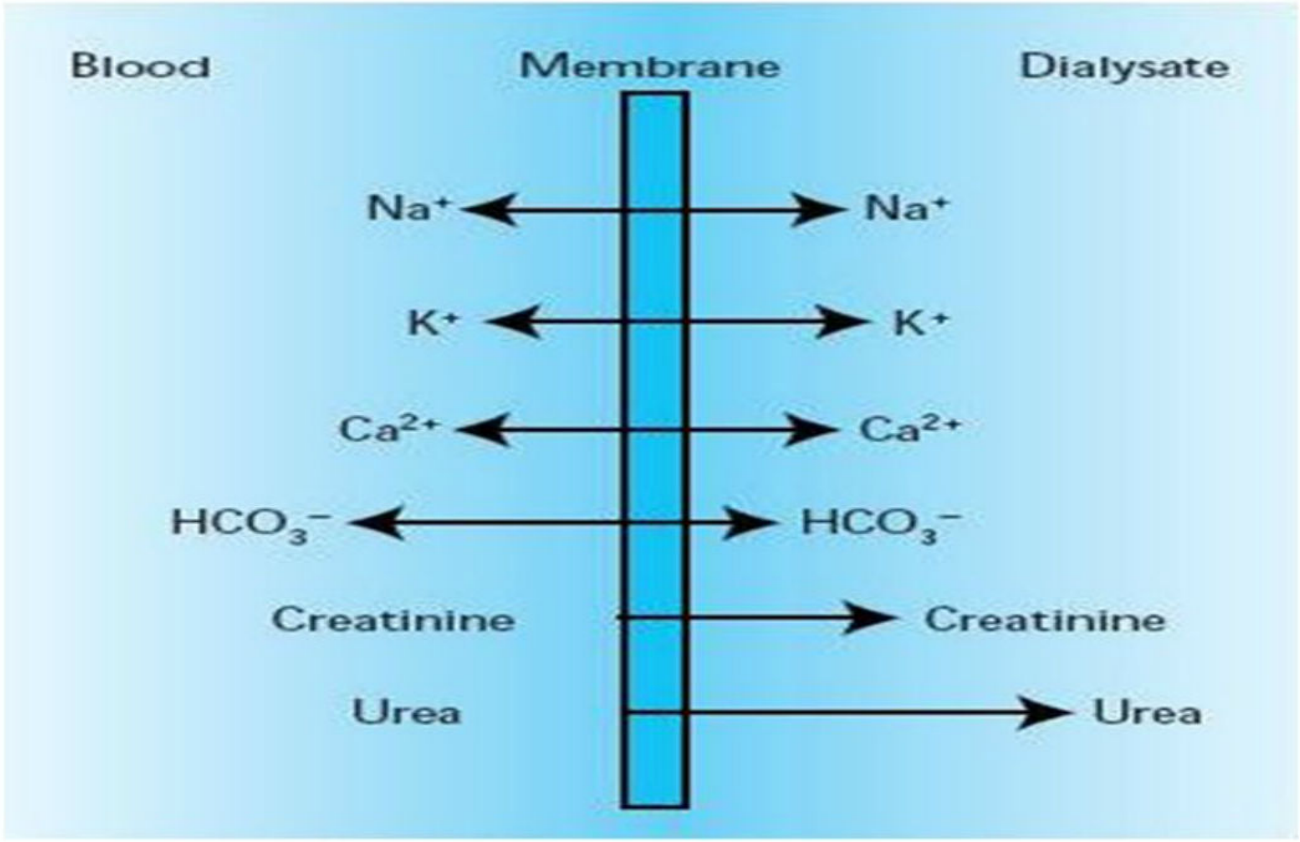
- **Extracorporeal- Hemodialysis**

  Blood is purified by an artificial kidney – 3-6 Hrs per week.

- **Intracorporeal – Peritoneal Dialysis**

  The peritoneal membrane of the peritoneal cavity is used for removing the waste products .

PRINCIPLE

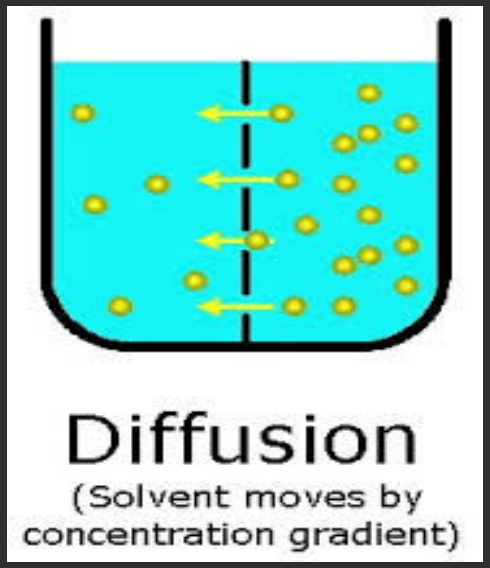

Blood
Membrane
Dialysate
Na^+
Na^+
K^+
K^+
Ca^{2+}
Ca^{2+}
HCO_3^-
HCO_3^-
Creatinine
Creatinine
Urea
Urea

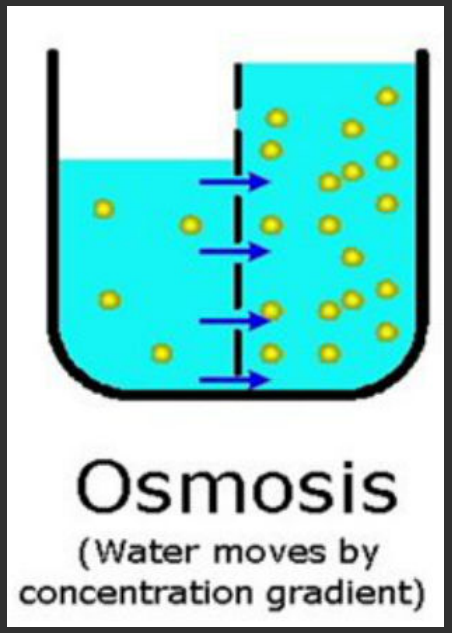
Dialysate Bath

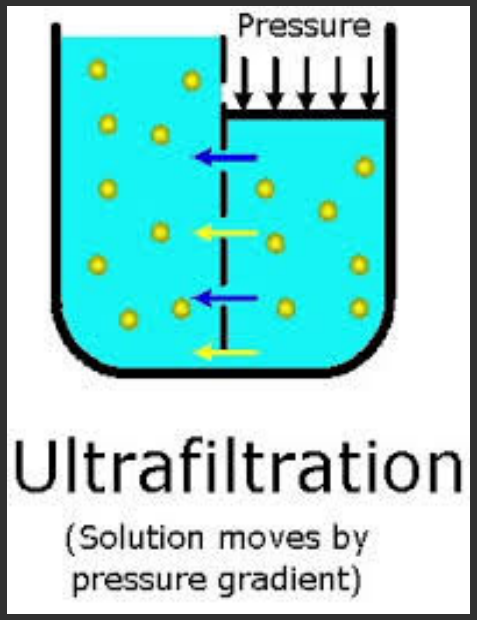
Concentrations of dialysate components used in hemodialysis

Sodium (meq/L)	135 to 155
Potassium (meq/L)	0 to 4
Calcium (mmol/L)	1.25 to 1.75 (2.5 to 3.5 meq/L)
Magnesium (mmol/L)	0 to 0.75 (0 to 1.5 meq/L)
Chloride (meq/L)	87 to 120
Bicarbonate (meq/L)	25 to 40
Glucose (g/dL)	0 to 0.20

Principle of Dialysis

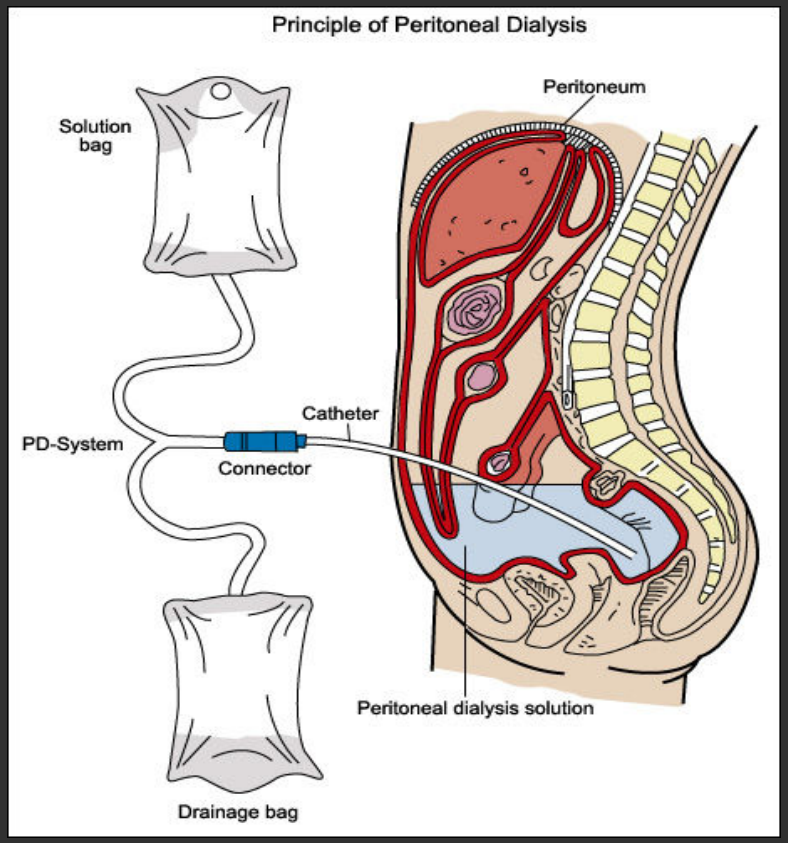






PERITONEAL DIALYSIS

- Peritoneal membrane = partially permeable membrane
- Dextrose dialysate
- Diffusion and Osmosis until equilibrium



- Dialysis fluid is introduced to the peritoneal cavity through a catheter placed in the lower part of the abdomen.
- A thin membrane, called the peritoneum, lines the walls of the peritoneal cavity and covers all the organs contained in it.
- In PD the peritoneum serves as the dialysis membrane. The peritoneal cavity can often hold more then 3 litres, but in clinical practice only 1.5 – 2.5L of fluid are used.
- This is an intra-corporeal blood purification as no blood ever leaves the body of the patient.

- An osmotic pressure gradient is applied by the addition to the dialysis fluid of an osmotic agent which will “suck” fluid from the blood.
- The concentration of this osmotic agent is chosen to give just the fluid removal needed. In most cases glucose is used to create the osmotic pressure.
- Fluid is removed by ultrafiltration driven by an osmotic pressure gradient.

CAPD- Continuos Ambulatory Peritoneal Dialysis

- Continuous Ambulatory Peritoneal Dialysis, CAPD is most widely used; know as the manual method where each exchange is taken care of by the patient.
- Typically regime 4 bags x 2L/day.
- This means that the patient performs 4 bags during the day.

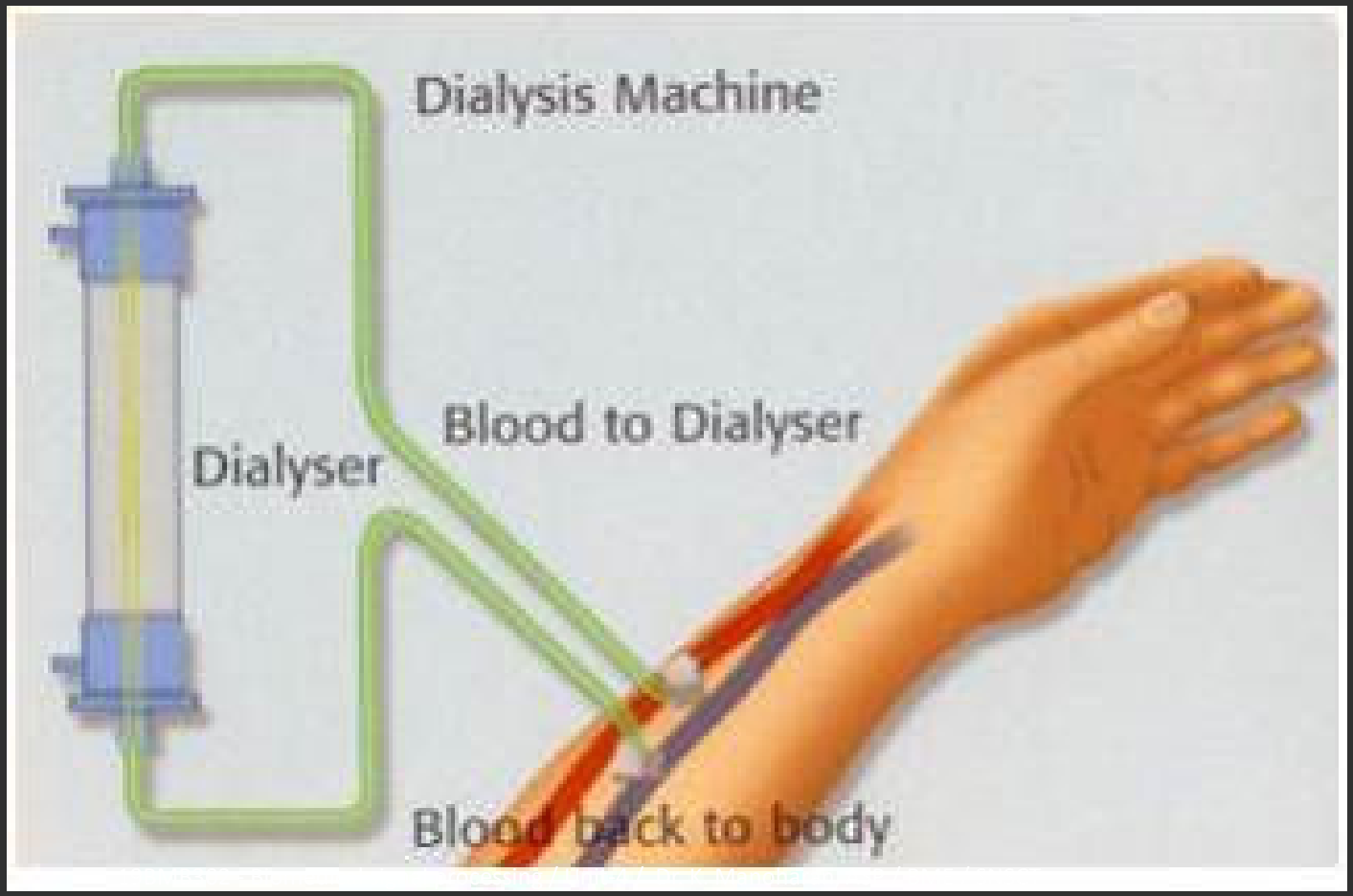
Disadvantages

- The treatment is performed with great hygienic care as the introduction of bacteria in to the abdomen can lead to peritonitis.
- Bacteria from the patients skin, equipment or from an unclean environment can be flushed into the abdominal cavity by the instilled PD fluid.
- The exit site of the catheter is also an infection route.
- In rare cases bacteria may enter from the intestines

HEMODIALYSIS

- Hemodialysis is a method for removing waste products such as creatinine and urea, as well as free water from the blood when the kidneys fail in their function.

Basic extracorporeal circulation



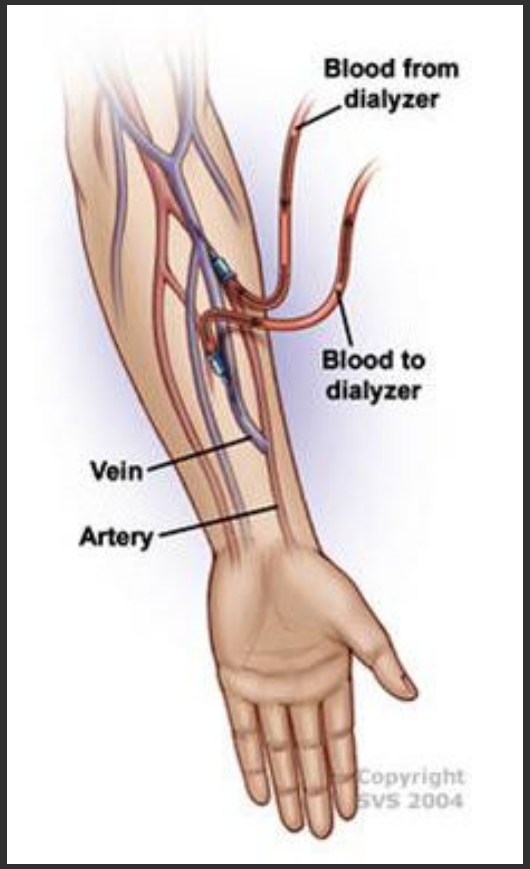
Access

- Arteriovenous fistula (AVF)
- Graft
- Tunneled catheter

Arteriovenous Fistula

- Highest patency
- Lowest risk of infection
- Low risk of thrombus

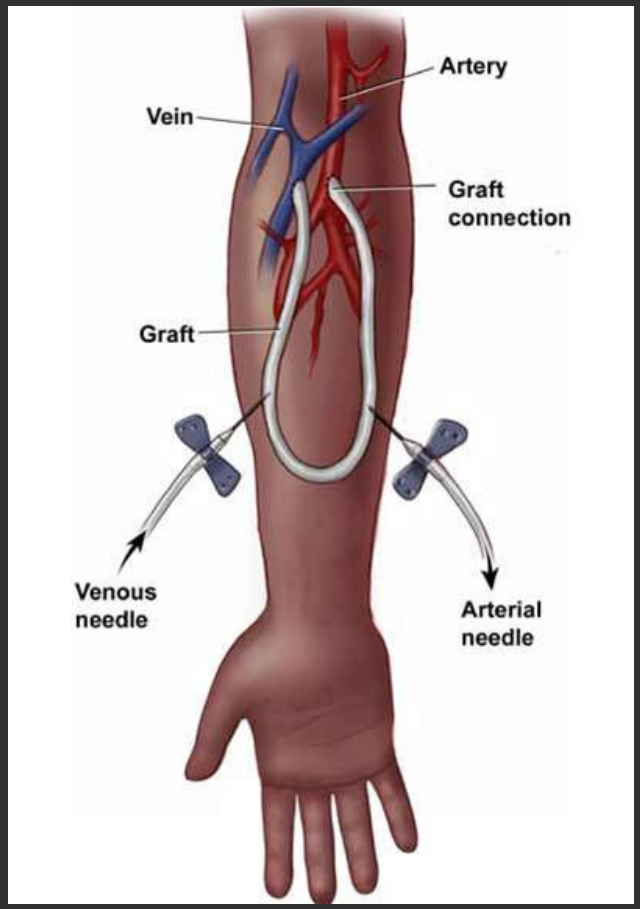
- Maturation time (3-4weeks)
- Steal syndrome (poor blood supply to the rest of the limb)
- Aneurysm formation



Arteriovenous Graft

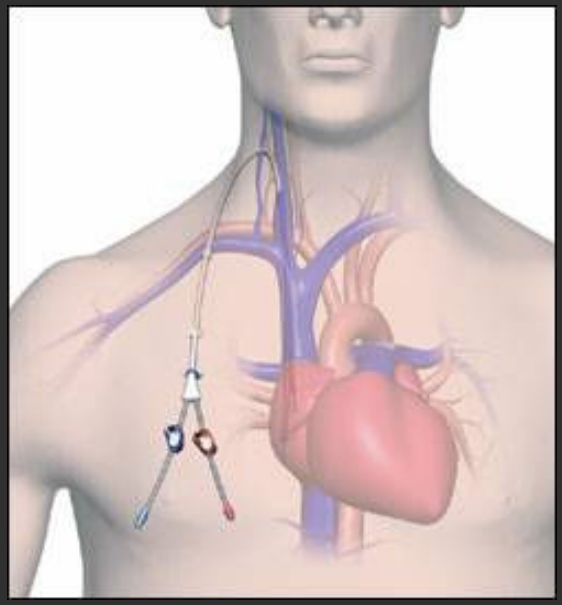
- Easier to create
- Maturation time 3-6 weeks

- Poor patency (often requires thrombectomy or angioplasty)
- Infection
- Aneurysms
- Steal syndrome



Tunneled Catheter

- Immediate use
- Bridge to AVF/AVG
- Poor flow (decreased HD efficiency)
- High infection risk
- Venous stenosis
- Thrombosis



Artificial Kidney

- The mechanical device used to clean the patients blood is called a dialyser, also known as an artificial kidney.
- A dialyzer is an artificial kidney designed to provide controllable transfer of solutes and water across a semipermeable membrane separating flowing blood and dialysate streams.
- The transfer processes are diffusion (dialysis) and convection (ultrafiltration).

Basic Dialyzer Types

- Coil
- Parallel plate
- Hollow fiber configurations

Coil dialyzer

- An early design in which the blood compartment consisted of one or two long membrane tubes placed between support screens and then tightly wound around a plastic core.
- No uniform dialysate flow distribution across the membrane.

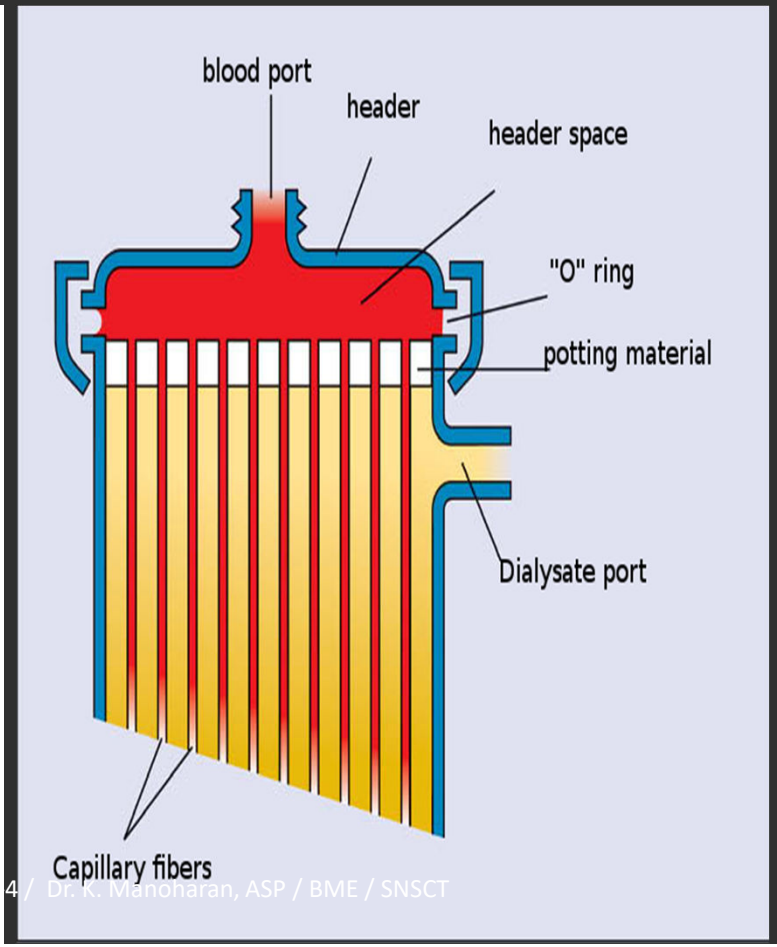
Parallel Plate Dialyzer

- Sheets of membrane are mounted on plastic support screens, and then stacked in multiple layers ranging from 2 to 20 or more.
- This design allows multiple parallel blood and dialysate flow channels with a lower resistance to flow.
- The **Physical size, Priming, Handling problem.**

Hollow Fiber Dialyzer

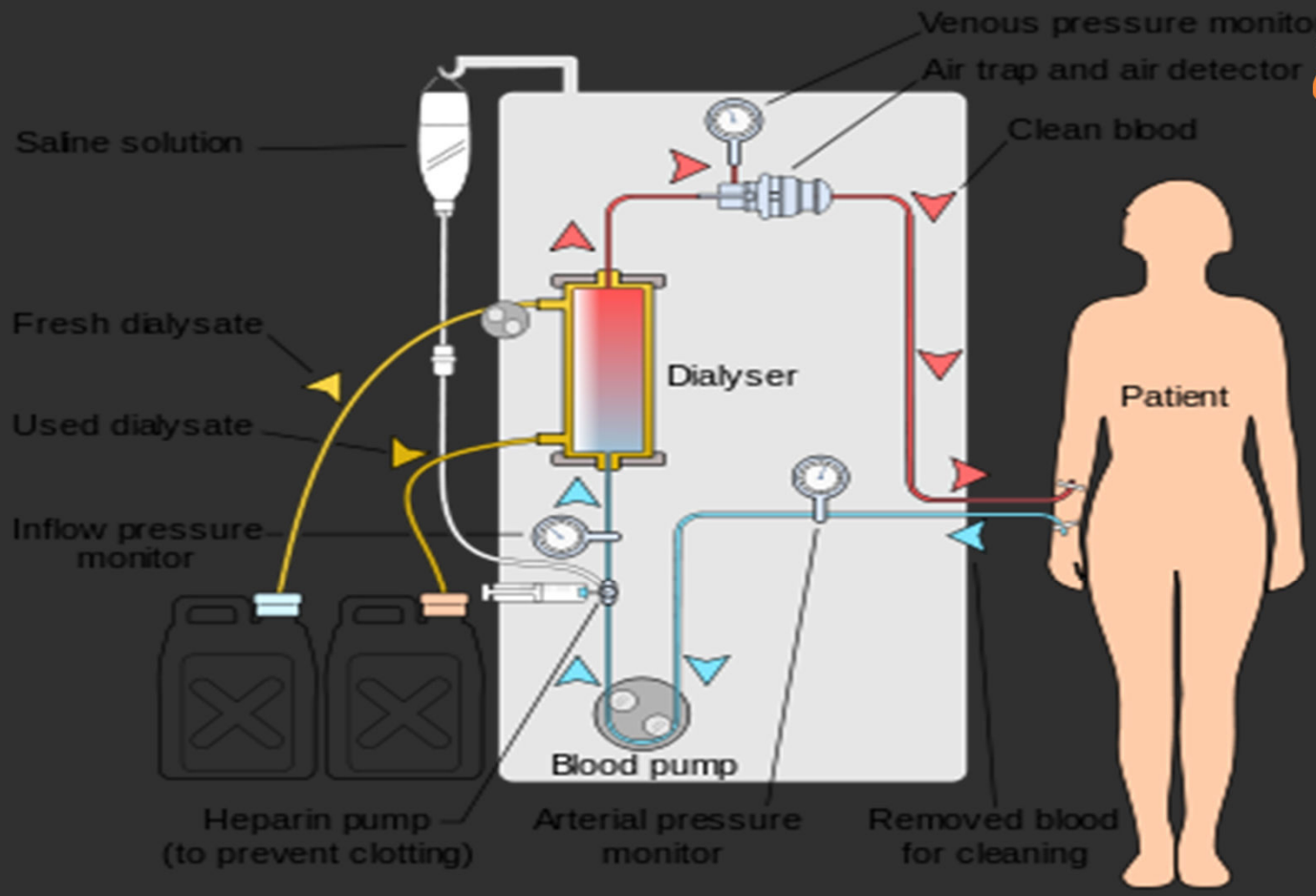
- Most effective design for providing low-volume high efficiency devices with low resistance to flow.
- The fibers in the device are termed the fiber bundle.
- The fibers are potted in polyurethane at each end of the fiber bundle in the tube sheet, which serves as the membrane support.

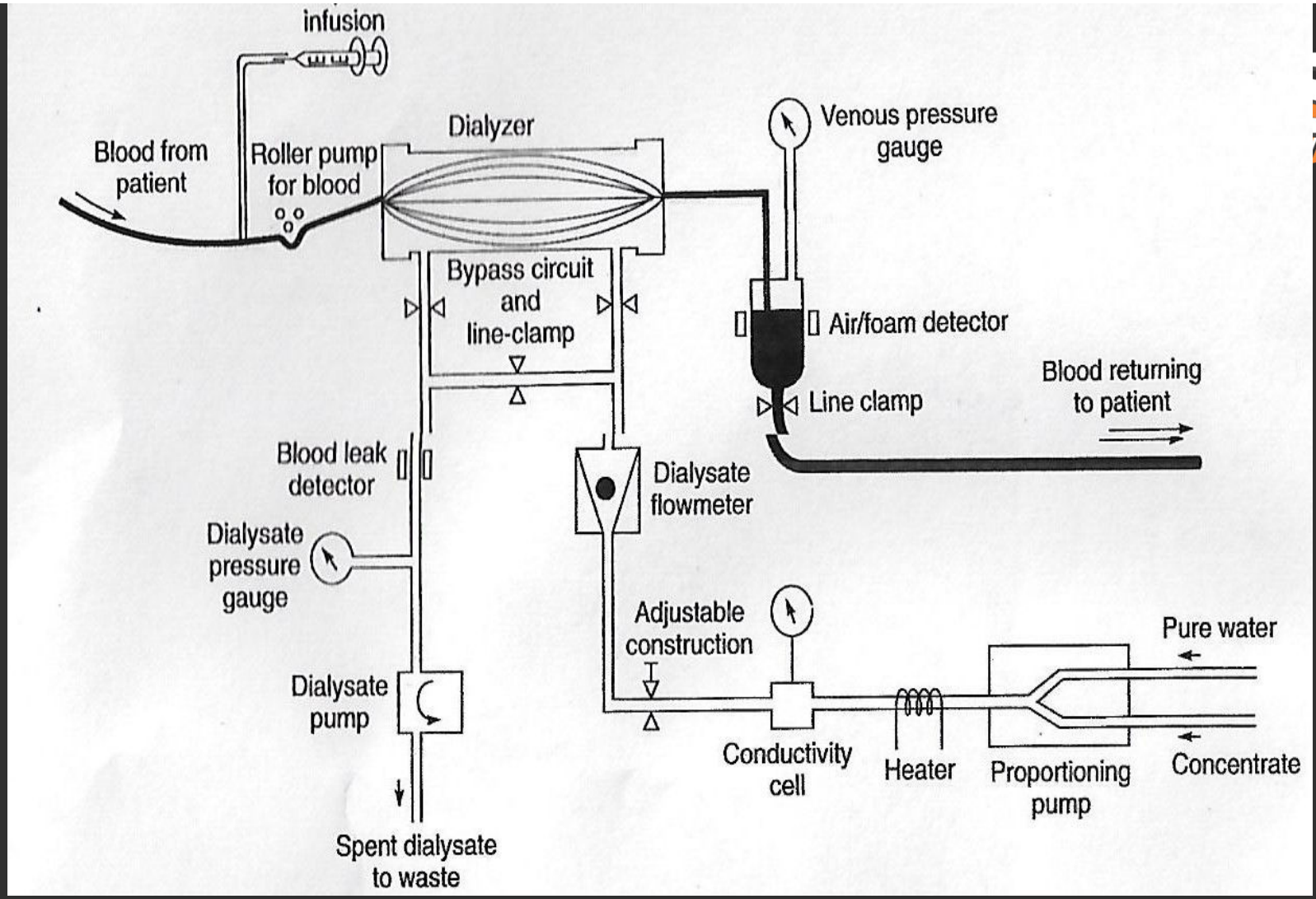
Hollow Fiber Dialyzer



Ultrafiltration

- Use of hydrostatic pressure gradient to induce convection (filtration of water).
- Solvent drag (pulls dissolved solutes) across.
- Removal of excess fluid by applying positive or negative pressure.


Venous pressure monitor
Air trap and air detector
Saline solution
Clean blood
Fresh dialysate
Dialyser
Patient
Used dialysate
Inflow pressure monitor
Blood pump
Heparin pump (to prevent clotting)
Arterial pressure monitor
Removed blood for cleaning


infusion
Blood from patient
Roller pump for blood
Dialyzer
Venous pressure gauge
Bypass circuit and line-clamp
Air/foam detector
Line clamp
Blood returning to patient
Blood leak detector
Dialysate flowmeter
Dialysate pressure gauge
Adjustable construction
Pure water
Dialysate pump
Conductivity cell
Heater
Proportioning pump
Concentrate
Spent dialysate to waste

- A haemodialysis machine is used for the production of warm dialysate which is then circulated through an external dialyser assembly.
- It controls the cycling of blood from patient through the artificial kidney (dialyzer) and back to the patient.
- It continuously monitors and controls all important parameters, automatically halting treatment in the event of parameters going out of preset limits.

5 Basic functions

- It mixes the dialysate.
- Monitors the dialysate
- Pumps the blood and controls the administration of anticoagulant.
- Monitors the blood for the presence air and drip chamber pressure.
- Monitors the ultra-filtration rate.

- The machine is designed to meet individual therapy requirements.
- The machine pumps and controls the blood flow from the patient through the dialyzer at a predetermined rate and pressure to ensure effective clearances and fluid interval in a specified time period.
- Ultra-filtration rate meter provides the measure in kilograms per hour

Dialysate Temperature Control and Measurement

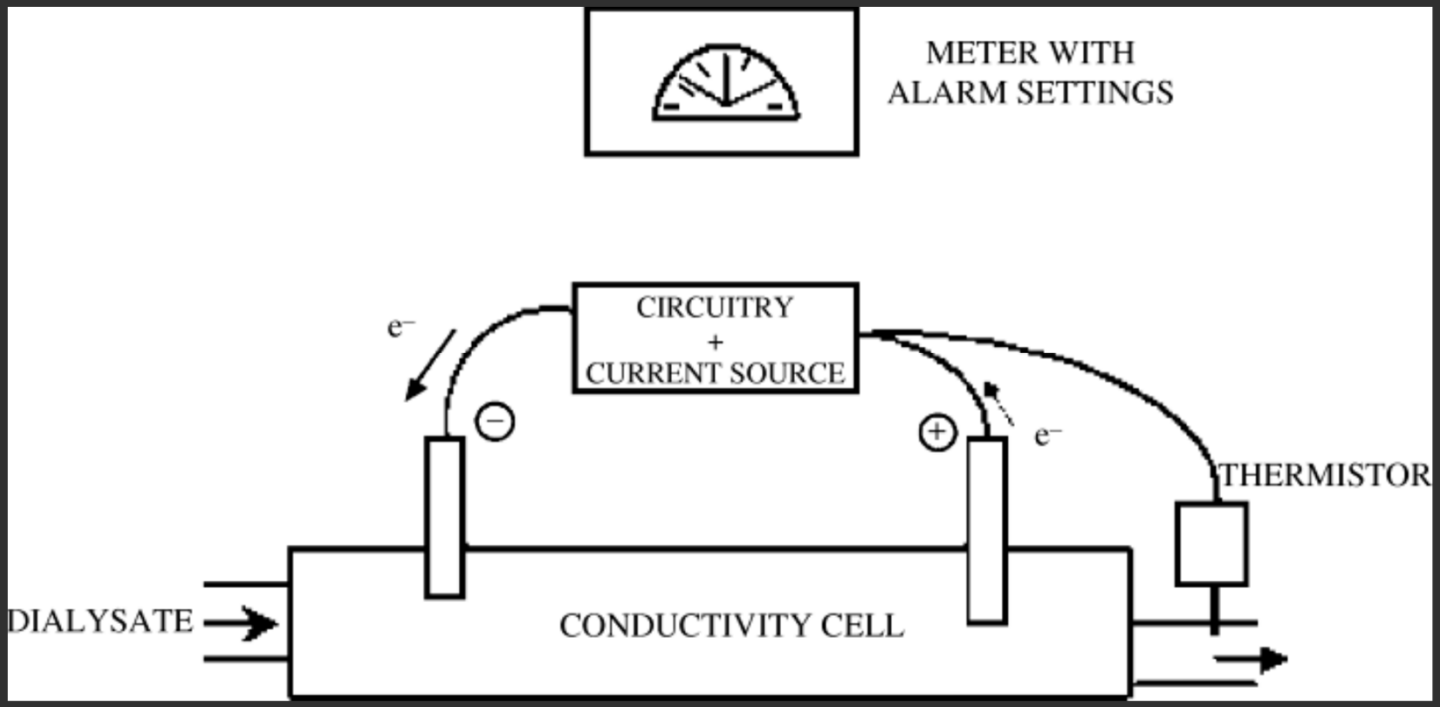
- Dialysis normally done at body temperature.
- Lower than body temperature, dialysis is less efficient and blood has to be warmed before return to patient.
- Required temperature varied from $36^{O}C$ to $42^{o}C$.
- Low temperatures can cause shivering.
- High temperatures can cause protein denaturing or hemolysis.

- Two types of circuit for control of temperature
- - Bi-metallic thermostat.
- - Electronic proportional controller.

Conductivity

- Is the amount of electrical current conducted through a dialysate and reflects electrolyte concentration.
- Conductivity should be between 12–16mS/cm (millisiemens per centimeter).
- The greater the number of ions, the greater the conductivity of the dialysate.
- Conductivity can be affected by temperature, or concentration of acid to base .
- Alarms will stop dialysate flow if conductivity is out of limits

Alarms—Temperature and Pressure Monitors



Pressure Monitor

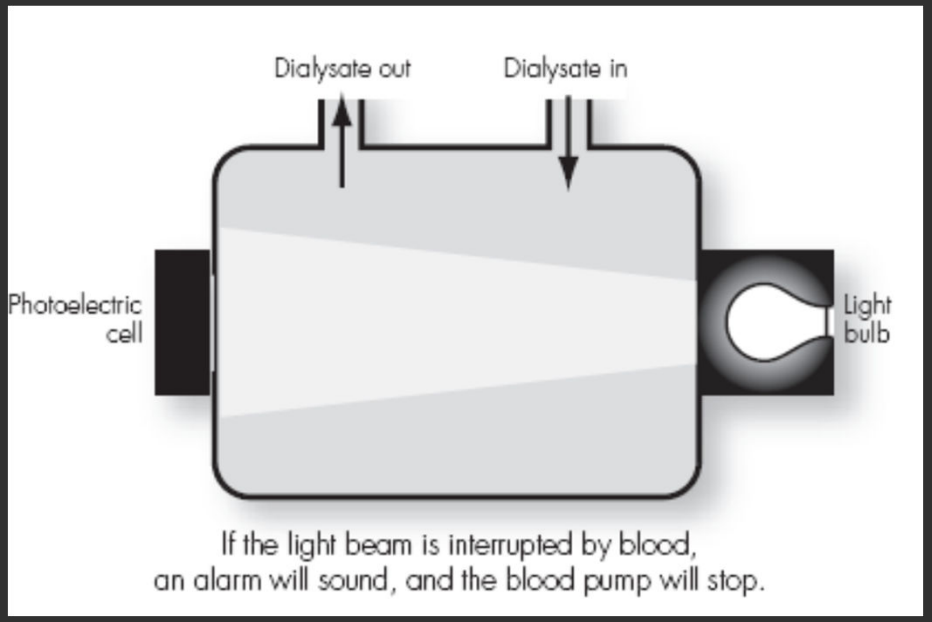
- The pressure range is – 400 to +350 mmHg with an accuracy of ± 10%
- Alarm limits are set at ± 10% of the pressure setting
- Pressure in the dialysate compartment should not exceed that in the blood compartment.

- Ultrafiltration (UF) is controlled by transmembrane pressure (TMP)
- TMP = PBO – PDO
- Ultrafiltration is the process of removing fluid from the patient in a controlled fashion, during which volume is accurately measured.

Blood Leak Monitor

- Blood should not cross the blood/dialysate membrane
- Leakage of blood into the dialysate circuit is detected by the blood leak monitor, which is usually located downstream from dialyzer
- Infrared or photoelectric cells detect decreases in light from source
- Red blood cells scatter light and trigger alarm, which deactivates the blood pump

Blood Leak Monitor Principle



Dialysis

- Time: 2-5 hours
- Bath
- Blood flow rate: 400-450ml/min
- Dialysate flow rate: 500-800ml/min
- Anticoagulant
- Additives:
  - Anemia (EPO, blood)
  - Bone metabolism (vit D, calcitriol, etc)
  - Medicines (antibiotics)

Dialysate Disinfection and Rinsing

- Dialysis machines should be disinfected according to the manufacturer's recommendations
- .The dialysate circuit should be exposed to disinfectant •
- Disinfectants and rinse solutions include:
  - Formaldehyde
  - Hypochlorite (bleach)
  - Peracetic acid

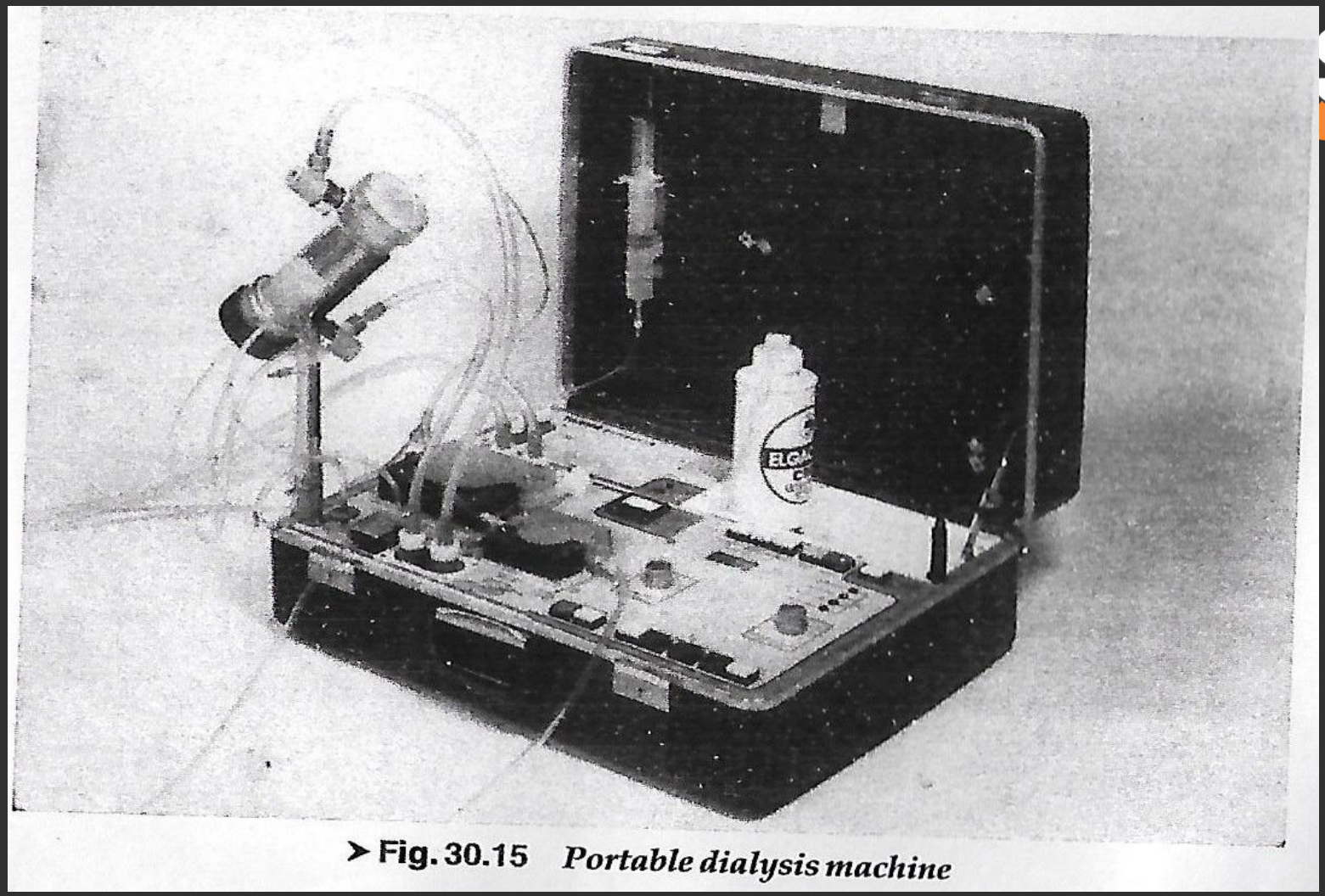
- Machines should be rinsed between chemicals and before a dialysis session
- Dead space is needed between dialysate effluent line and drain
- Some dialysis machines incorporate a bacterial and endotoxin-retentive ultrafilter that prevents bacterial contamination. This is termed “ultrapure dialysate”

Emergencies—Power

- In the event of loss of power, the system is no longer safe for dialysis patients.
- Blood should be returned manually to patients and patients taken off the machine if power is not restored in 15–30 minutes.

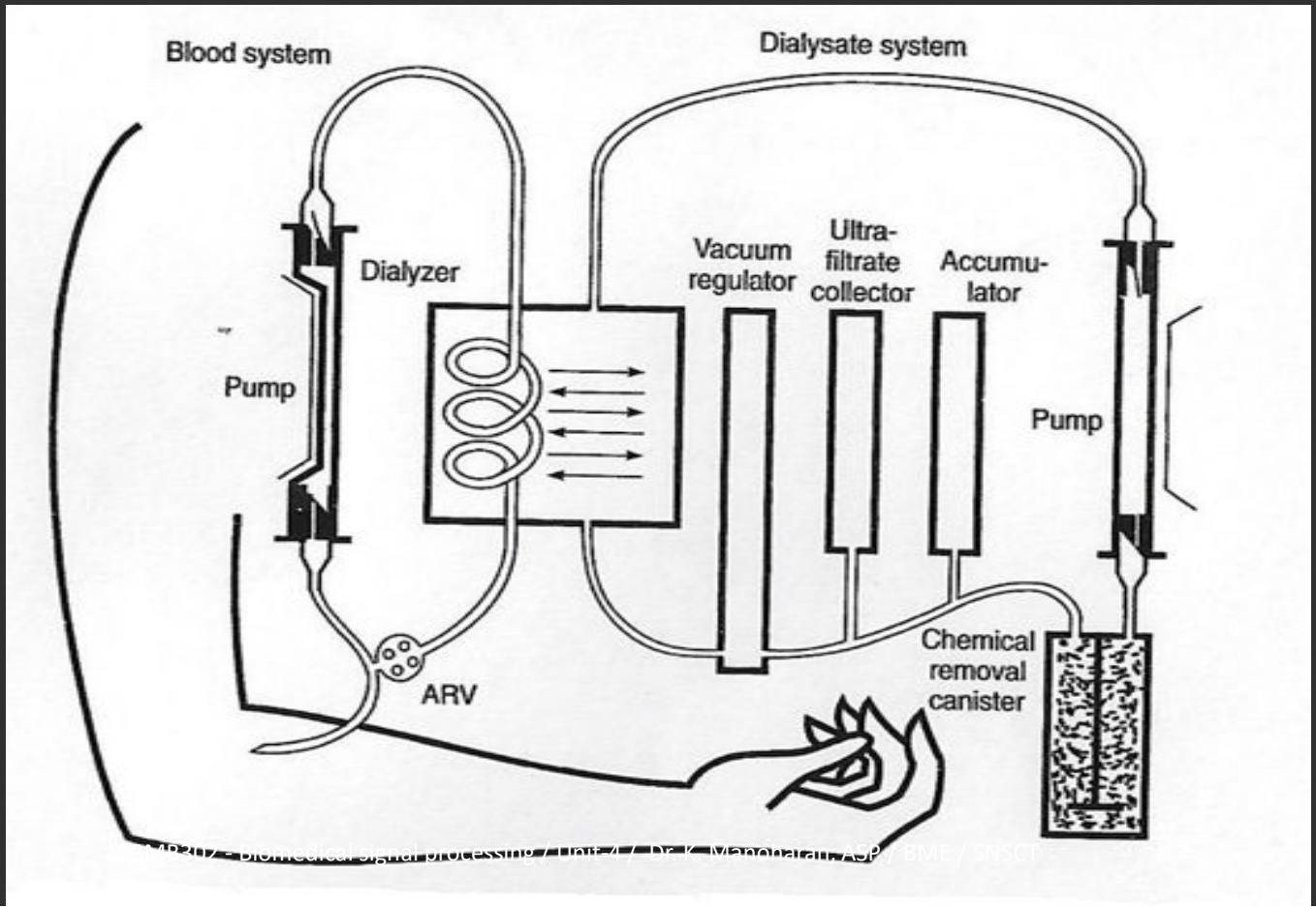
Portable Hemodialysis

- Home Dialysis
- Works on 12V rechargeable battery.
- Compact in size
- Single pump for Blood and Dialysate
- Wearable Artificial Kidney (WAK)
- 20 litres of Dialysate collapsible bag (dialysate powder sachet + ionized water)
- 250gram of activated charcoal
- Hollow fibre dialyser
- BFR – 600 ml/min , fluid exchange – 12L/hr, fluid removal - 2.4L/min



➤ Fig. 30.15 *Portable dialysis machine*

Portable Wearable Kidney



Portable Dialysis

Portable Dialysis

Don’t treat them lightly

“They’re willing to throw in their kidneys.”

Thank You!