SNS COLLEGE OF ALLIED HEALTH SCIENCES

SNS Kalvi Nagar, Coimbatore - 35

Affiliated to Dr MGR Medical University, Chennai

DEPARTMENT OF CARDIO PULMONARY PERFUSION CARE TECHNOLOGY

COURSE NAME : PRINCIPLES OF PERFUSION TECHNOLOGY I

II YEAR

TOPIC : SAFETY DEVICES

FLOW METERS

- The centrifugal pumps and the non –occlusive pumps are pressure sensitive, so they require a separate sensor of a flow meter.
- ***Flow meters are used to monitor the blood flow of the pump.***

LOCATION OF FLOW METER IN ECC

- The flow meter should be incorporated into the ***"arterial outflow".***

- The flow meter can also be located downstream of any ***"purge"*** or ***"recirculation line"*** in the circuit to accurately measure blood flow delivered to the patient.

TYPES OF FLOW METERS

- Flow meters are the indispensible part of the centrifugal pump.

- Two types of measuring techniques are used clinically, one is working with an ***ultrasonic principle***, the other with an ***electromagnetic principle.***

ELECTROMAGNETIC FLOW METER

- Electromagnetic flow probes depend on the fact that blood flowing through an electromagnet alters the magnetic field in a manner that can be measured continuously.
- It requires the connector that need to be build into the tubing and this will affect the blood flow.
- A disadvantage of the electromagnetic flow probes is that, there is the **difficulty in obtaining the good zero value**.

ULTRASONIC FLOW METER

- Ultrasonic flow meter is a type of flow meter that measures the velocity of a fluid with the ultrasound to calculate volume flow.

- ***The ultrasonic flow meter utilize either the Doppler principle or a variant known as ultrasound transit –time.***

DOPPLER ULTRASONIC FLOW METER

- In doppler ultrasonic flow meters an acoustic pulse is transmitted into the stream of liquid by the transducers.

- These transducers then receive an echo of the pulse reflected by the particles of matter within the fluid.

- By comparing the transmitted and reflected signals, the rate of the flow can be computed.

DISADVANTAGES OF DOPPLER PRINCIPLE

- The doppler principle is less frequently used in flow meter probes because the signal becomes ***"noisy"*** at low velocities and this results in inaccurate, low flow readings.

- It will only work properly if there is sufficient particulate material to reflect the pulses and if that material is flowing homogeneously within the fluid.

ULTRASOUND TRANSIT -TIME

- A transit –time flow probe consists of ***flow small piezoelectric crystals***, one "upstream" (i.e., against the flow) and one "downstream" (i.e., in the direction of flow) mounted in a common tip that can be clipped on the tubing.

- The time it takes for a signal to travel downstream is compared with the time taken for a signal to travel upstream velocity is then calculated.

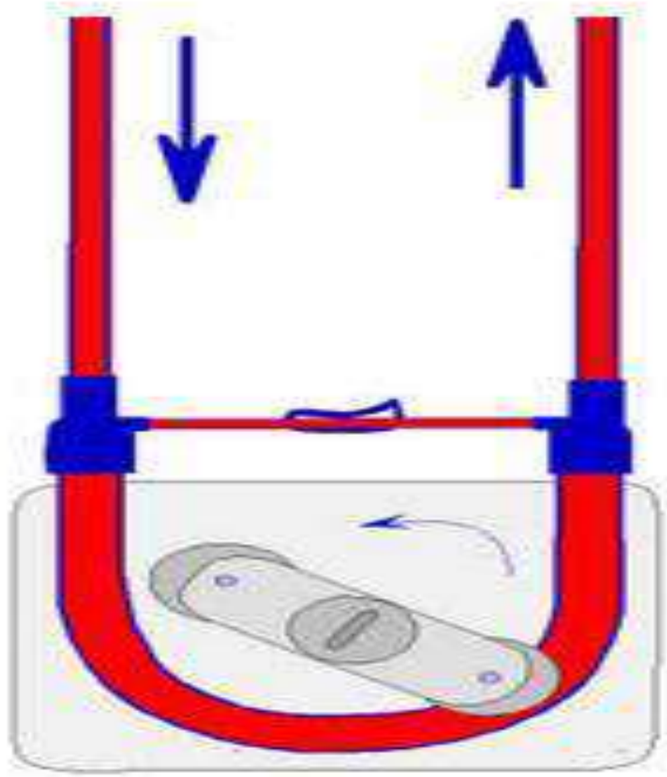
ADVANTAGES OF TRANSIT –TIME FLOW METERS

- Transit –time flow meters have an excellent correlation with direct measured blood flow evenly in very low flow ranges.

- They can be clipped on to the outside of the tubing and therefore no immediate contact between the blood and probe exists.

Ultrasonic Flow Sensor

Centrifugal Pump

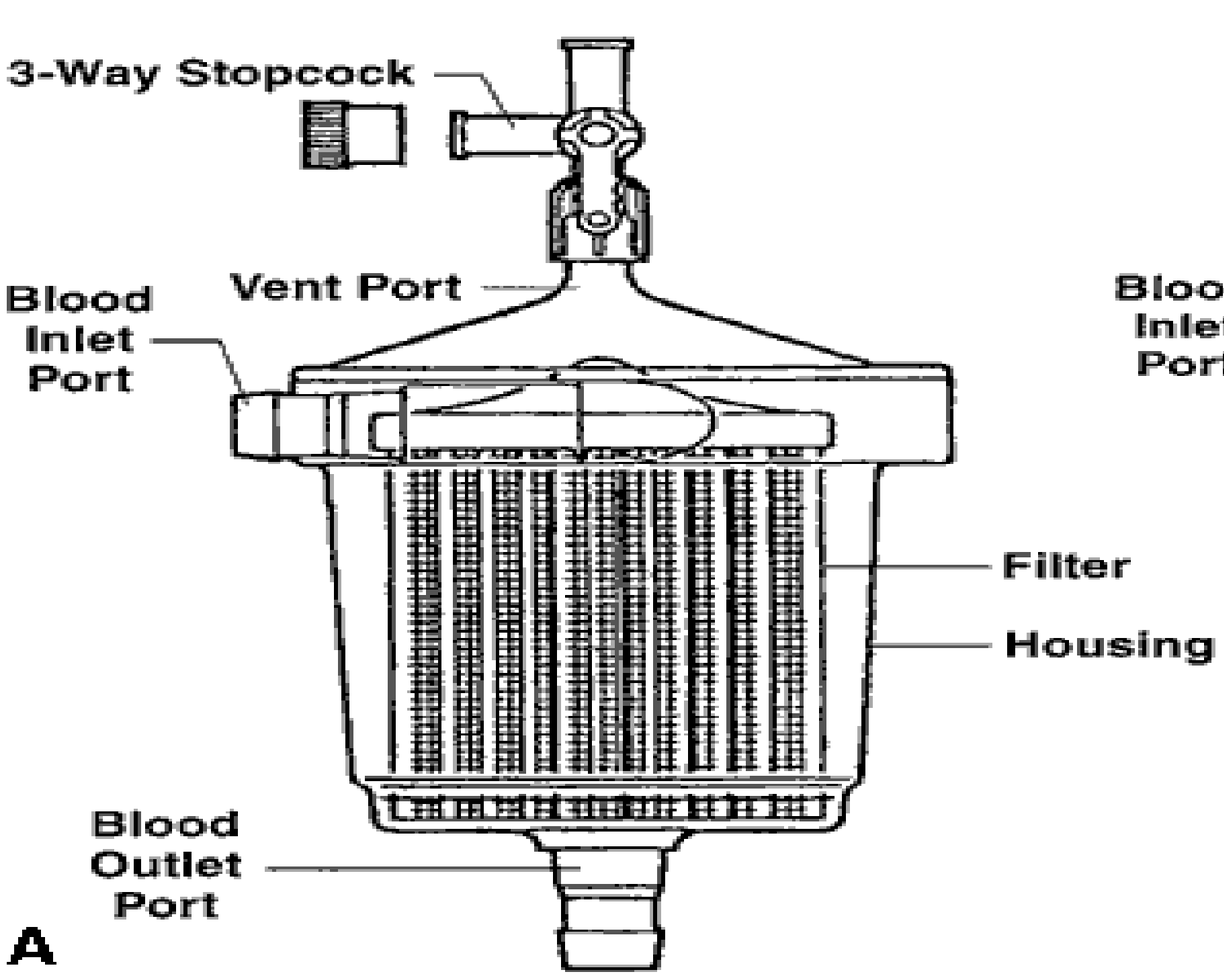


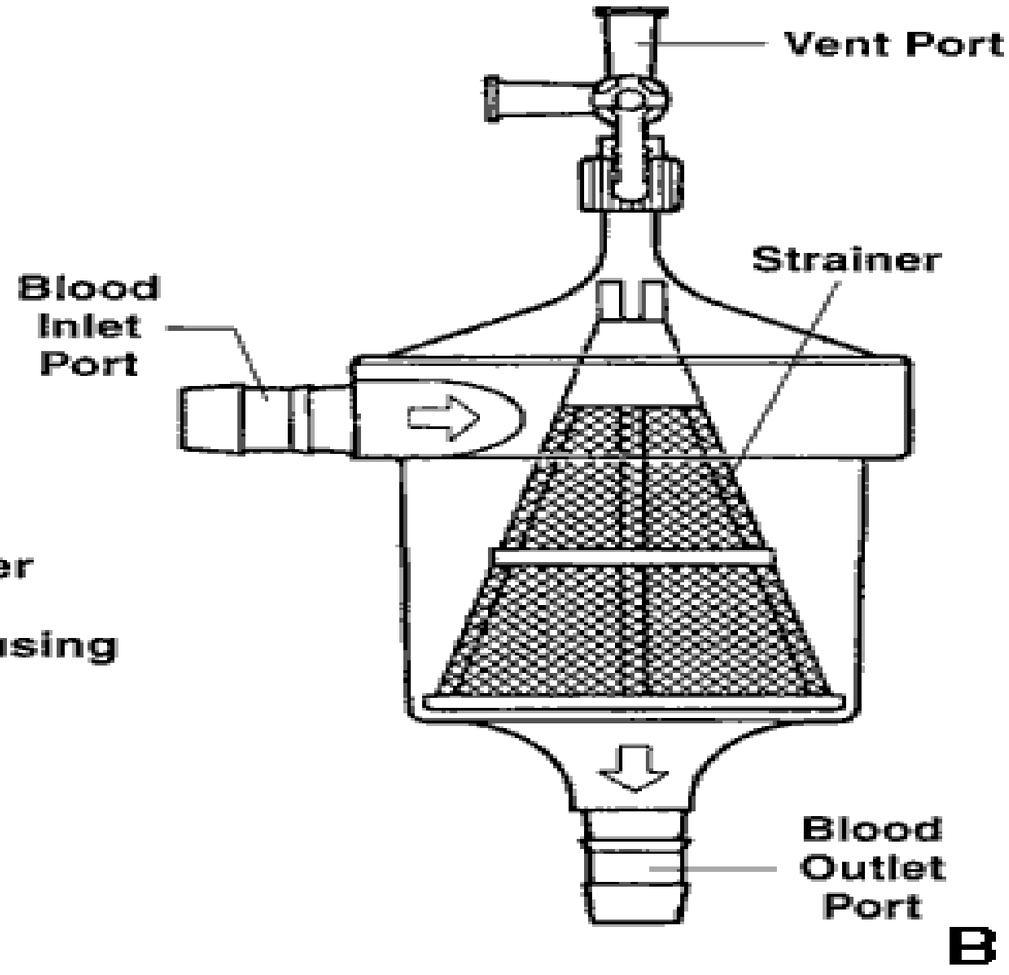
Roller Pump

BUBBLE TRAP

BUBBLE TRAP

- ***Bubble trap which removes air, micro emboli in the arterial blood***
- Bubble trap is placed in the arterial line between arterial filters.
- The bubble which is trapped in the bubble trap is then converted into a rotating stream.
- This unit is easily and quickly connected in the line using ***¼" connection.***
- The pressure rated up to ***30 psi*** are effective in debubbling of aqueous solution.
- When a fluid containing bubble which flow through the unit, the bubbles are forced through the ***"microporous hydrophobic membrane".*** Dynamic bubble trap reduce micro emboli during CPB.


3-Way Stopcock
Vent Port
Blood Inlet Port
Filter
Housing
Blood Outlet Port
A


Vent Port
Strainer
Blood Inlet Port
Blood Outlet Port
B

LEVEL SENSOR

LEVEL SENSOR

- *Level sensor is used to sense the level of blood in the reservoir.*

Uses:

- *It is needed to maintain oxygenator volume at a reasonable level, to allow the perfusionist time to react to sudden changes.*

TYPES OF LEVEL SENSOR

Types of level sensor:

- ***capacitance system***
- ***weight system***
- ***light system***

CAPACITANCE SYSTEM

- The capacitance system uses a strip of metal tape which is placed on the side of the oxygenator by the perfusionist at whatever level he wishes the alarm to sound and it does not stop the pump.

Level Detector (SAFETY)

LIGHT SYSTEM

- The light sensor type is a device which attaches to the oxygenator holder and is moved up against the side of the oxygenator at certain level it gives alarm.
- In the light sensor type, as long as blood is in-front of the light sources, the light is reflected back on the sensor. When the sensor does not see a reflected light the device alarms.
- The draw back to this device is, if a ***clot form infront of the light source, then the sensor will always see refected light***.

WEIGHT SYSTEM

- ***The weighting device actually weights the holder oxygenator and contents of the oxygenator.***
- As the weight in the oxygenator increases due to increasing volume, the arterial pump head runs faster in order to maintain a set arterial reservoir level.
- The disadvantage of this device is that the device cannot differentiate between blood in the arterial reservoir and someone leaning on the weight arm.

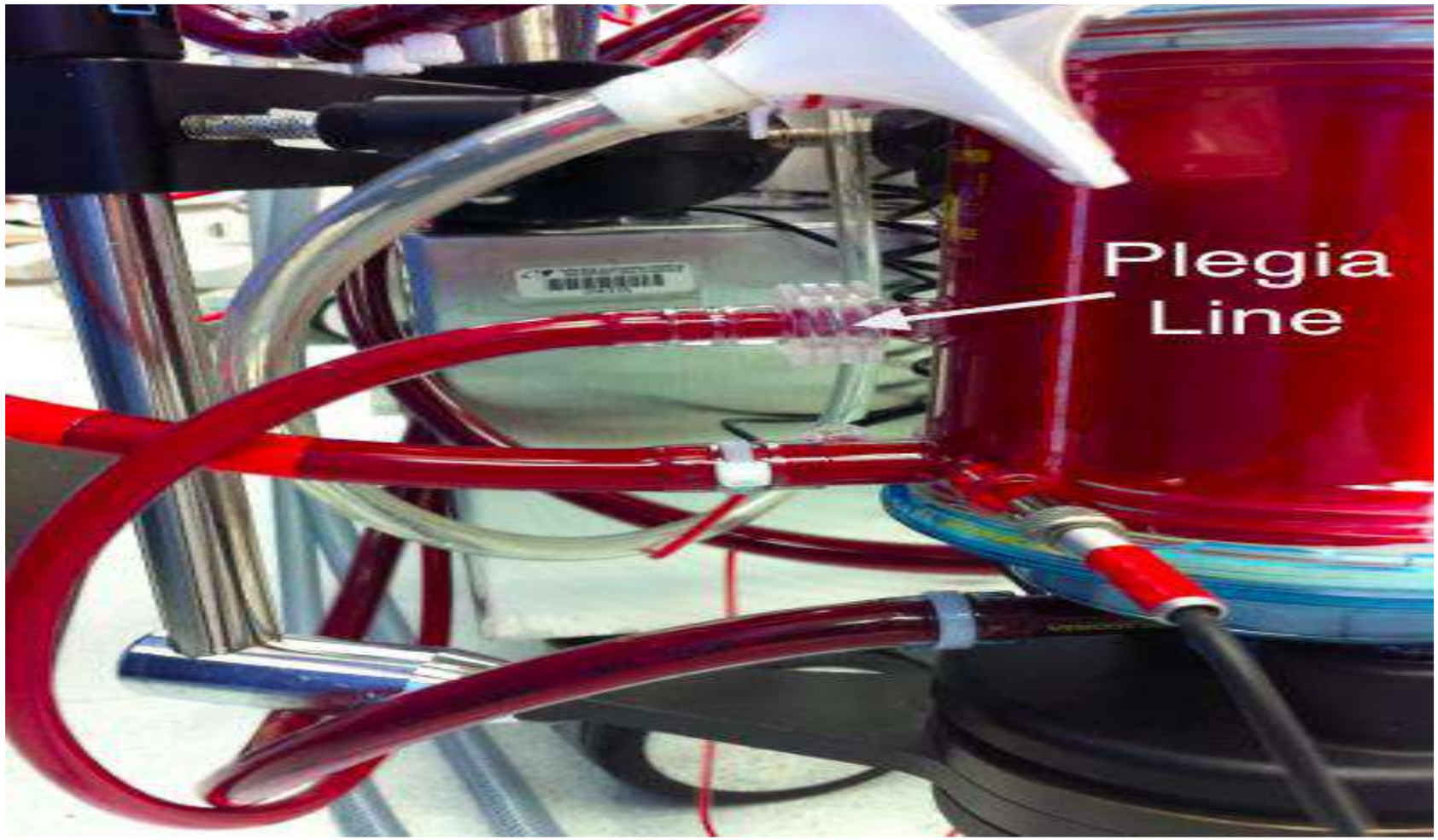
TEMPERATURE PROBE, BUBBLE DETECTOR& PRESSURE ALARMS

TEMPERATURE PROBES

- Accurate measurement of temperature certainly one of the most important parameters followed during hypothermic perfusion and rewarming.

- Temperature probes are incorporated in the ***venous inlet and at the arterial side of oxygenator.***

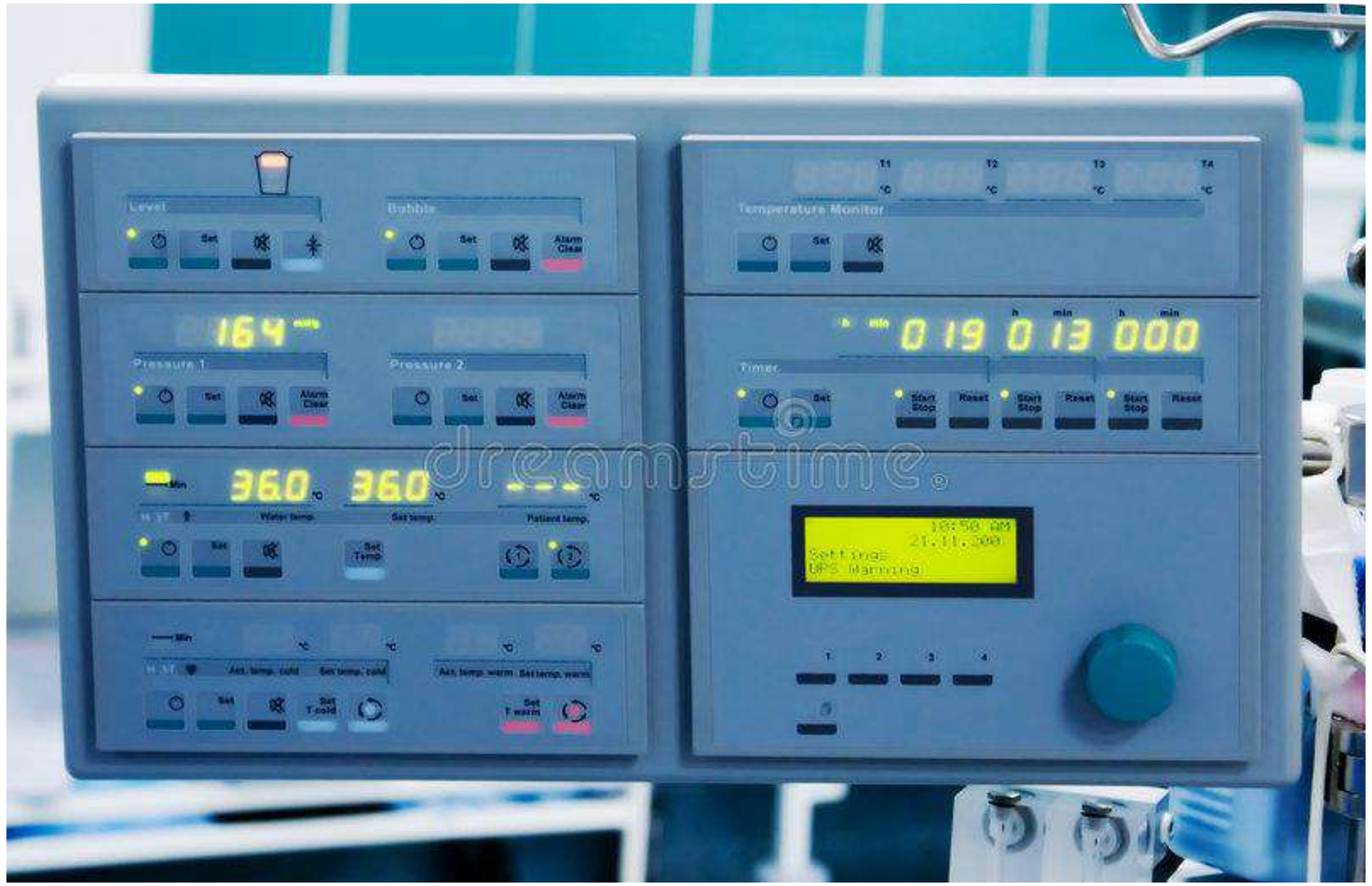
- In patients the temperature monitoring sites are, tympanic, nasopharynx, rectum during cardiac surgery.


Plegia
Line

BUBBLE DETECTORS& PRESSURE ALARMS

BUBBLE DETECTORS& PRESSURE ALARMS

- The bubble detector is used at the arterial inlet of the circuit, so that the air embolism cannot enter the patient.
- Most modern HLM have integrated electronic alarms for limits of pressure during a case. There limits should be detected and corrected to an appropriate time.


Level
Bubble
Set
Alarm Clear
Temperature Monitor
T1
T2
T3
TA
164
Pressure 1
Pressure 2
0 19 0 13 000
Timer
Start Stop
Reset
360
360
Water temp.
Set temp.
Patient temp.
Set Temp
Settings
UPS Warning
Act. temp. cold
Set temp. cold
Act. temp. warm
Set temp. warm
T cold
T warm

ARTERIAL FILTER

ARTERIAL FILTER

- The arterial filters remove air and particulate matter while allowing passage of cellular elements of blood.
- In modern practice, screen arterial line filters are made of nylon or polyester are almost universally used generally with a pore size of **40 µm**. Surface area varies between 650 –800 cm2.

LIMITATIONS

- Relatively ***large priming volume*** (200ml) is required to prime the filters.

- Problems related to cellular components of blood –***Hemolysis, platelet loss and complement activation***.

- ***Lack of proven benefit***

- A paradoxical risk of increased particulate ***embolism.***

SPECIFIC ARTERIAL FILTER

- Pall Biomedical
- Terumo Capiox
- Dideco736

LEUKOCYTE DEPLETION FILTER

LEUKOCYTE DEPLETION FILTER

- Leukocyte depletion filter contain non woven polyester fibers that have been surface modified to remove leukocytes.
- Neutrophil are important contributor to ischemia reperfusion injury. Neutrophils causes tissue injury by release of enzymes, reactive oxygen species and other toxic substances.

LEUKOCYTE DEPLETION FILTER

- Neutrophil filtration in CPB circuit has been proved beneficial to provide myocardial protection.
- LD filters may be placed in many different locations in the ECC, including arterial line, venous line and cardioplegialine.

Disadvantage:

- LD filters is that it adds further prime volume to the circuit.


ACEWELL
MEDICAL INDUSTRY
Acewell
Medical Industry Co., Ltd.

CARDIOTOMY FILTER

CARDIOTOMY FILTER

- ***Suckers return the blood from the surgical field*** to cardiotomy. This blood contains the usual suction debris such as fat particles and bone chips.

- Because of the turbulence of the suction, there are also ***large number of air bubbles in the carrying blood.***

- Therefore the reservoir integrate a ***defoaming agent***.

- When using the cardiotomy reservoir, the perfusionist use the ***" unfiltered"*** cardiotomy, which usually has a pore size of 70 to 180 microns.
- They then filter the blood again prior infusing the patient. The use of a ***"filtered"*** cardiotomy with 30 –40 microns filter will eliminate more particulate matter.

BANKED BLOOD FILTER

BANKED BLOOD FILTER

- Banked blood filters are usually incorporating as 40 microns in size.

- This filters helps to prevent clogging with debris.

- This clogging would require the changing of a cardiotomyor a hardshellvenous reservoir, with an integral cardiotomy.

GAS FILTER

GAS FILTER

- Gas filters are used to remove any particulate matter that come from the gas source.

- Gas filters are usually 0.2 microns in pore size.

- They usually have an arrow marking in the direction of flow, although some models are bi –directional.

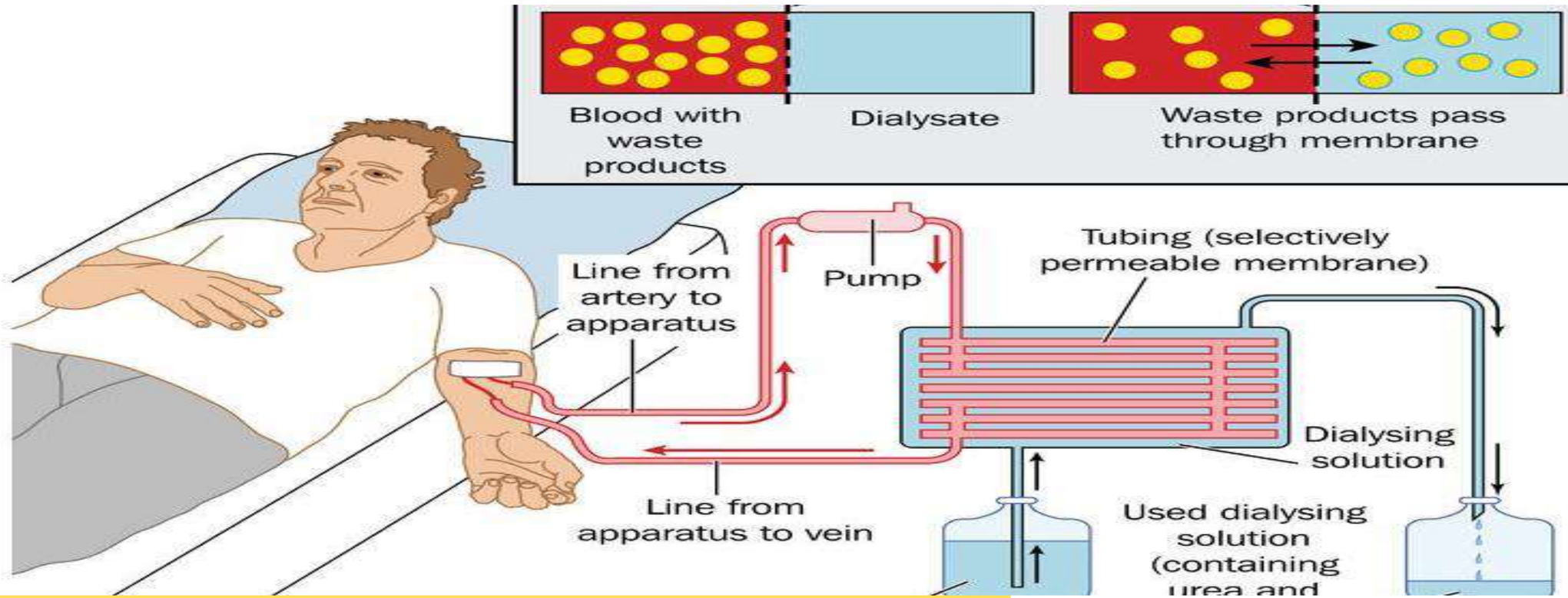
CARDIOPLEGIA FILTER

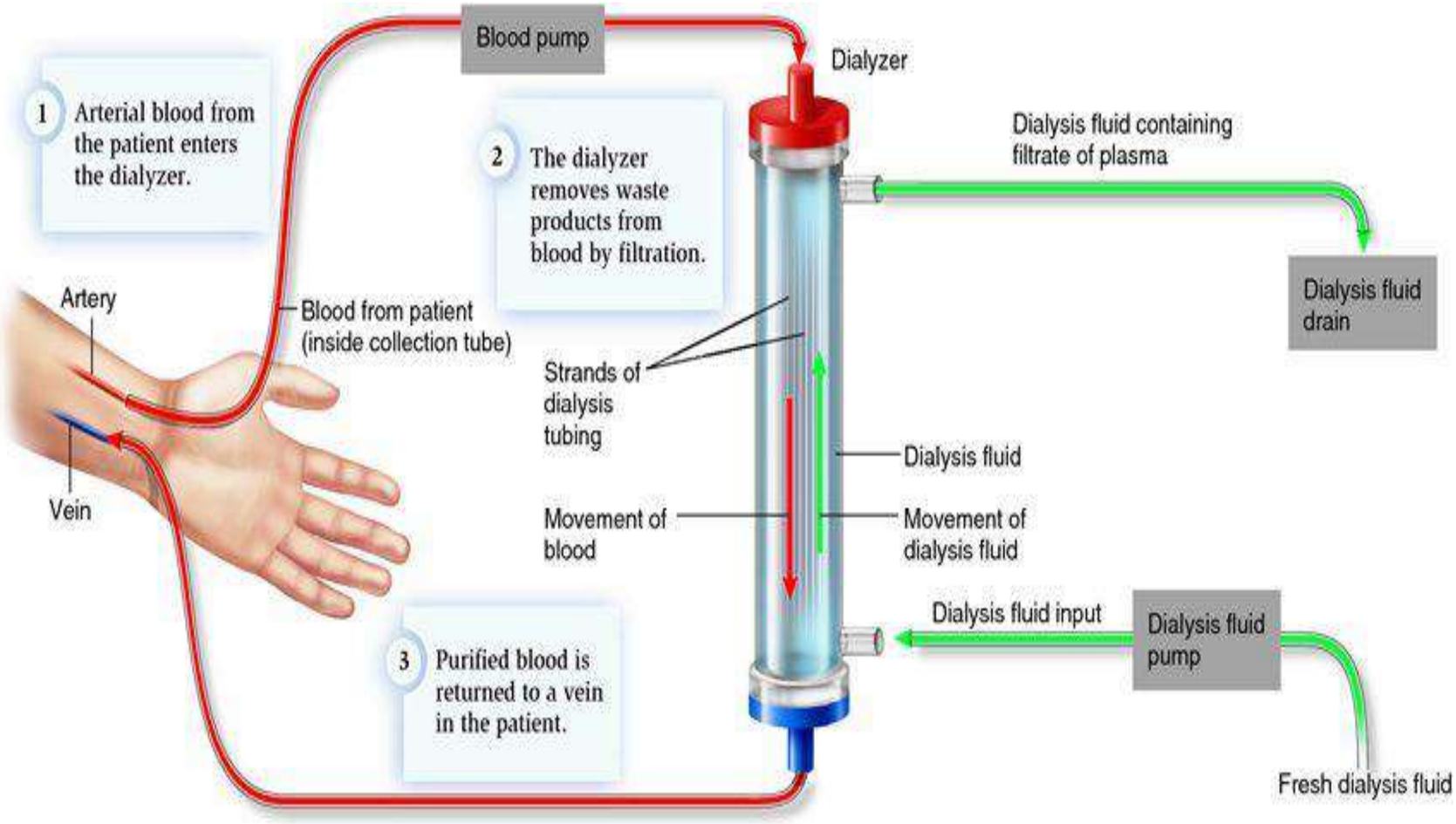
- Cardioplegia filters are available today to filter the crystalloid portion of the cardioplegia solution.
- These filters are in the 0.2 micron pore size range.

HEMOFILTER&ULTRAFILTRATION

DIALYSIS

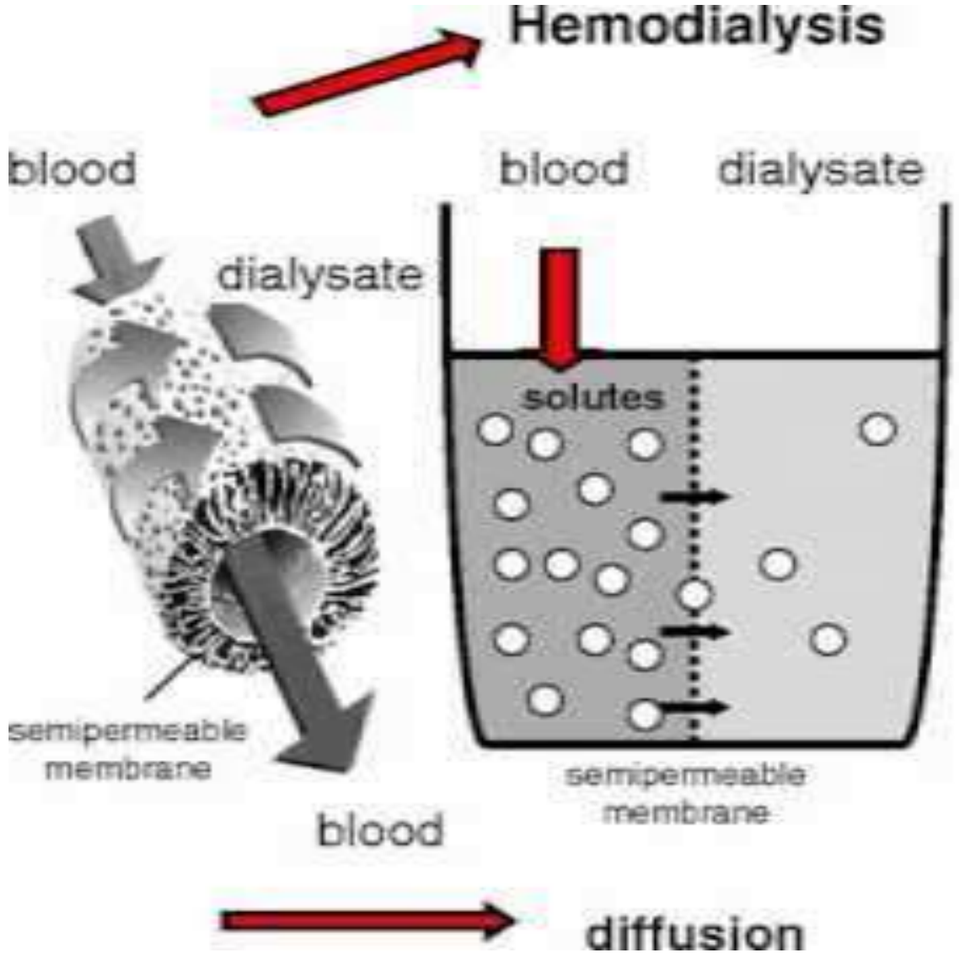
- ***Dialysis refers to a process in which blood is separated from crystalloid solution or dialysate by a semi permeable membrane.***

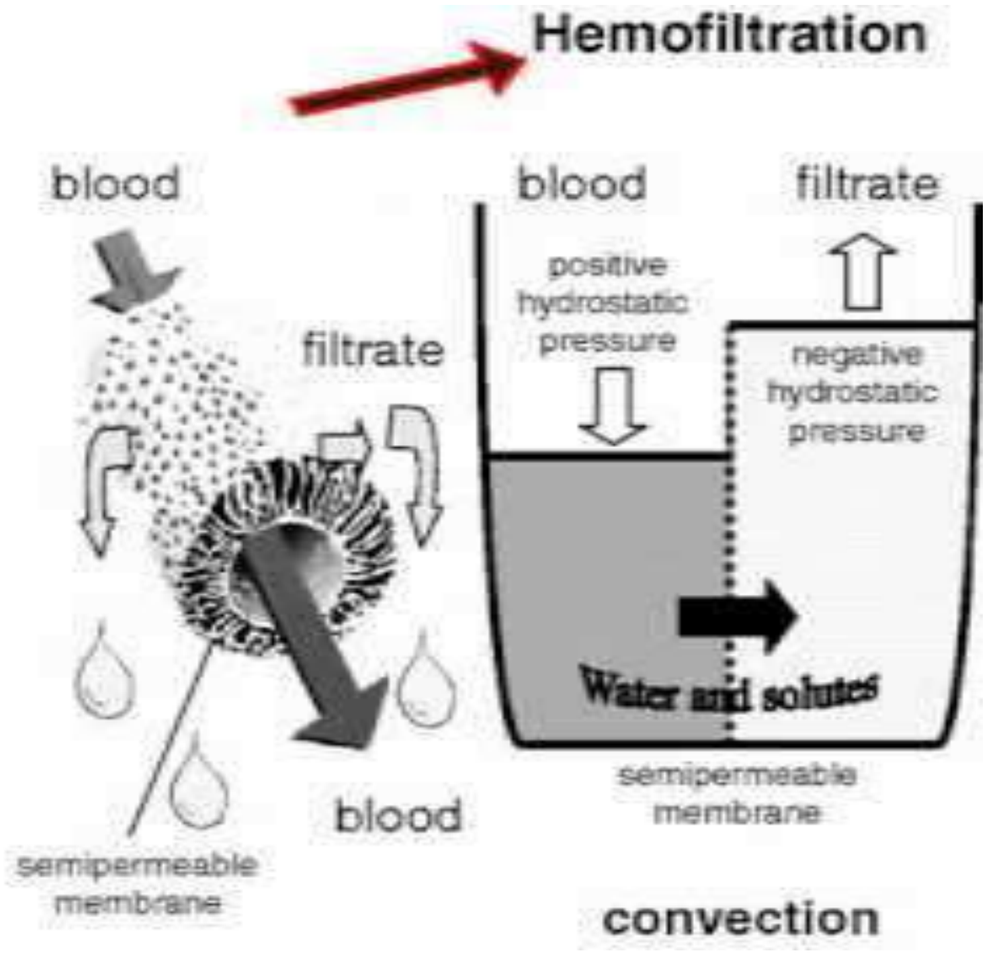



Blood pump
Dialyzer
1 Arterial blood from the patient enters the dialyzer.
2 The dialyzer removes waste products from blood by filtration.
Dialysis fluid containing filtrate of plasma
Dialysis fluid drain
Artery
Blood from patient (inside collection tube)
Strands of dialysis tubing
Vein
Dialysis fluid
Movement of blood
Movement of dialysis fluid
Dialysis fluid input
Dialysis fluid pump
3 Purified blood is returned to a vein in the patient.
Fresh dialysis fluid

ULTRAFILTRATION

- ***Ultrafiltration refers to movement of water across a membrane due to transmembrane pressure gradient. No dialysate on the opposite side of membrane is required.***


Hemodialysis
blood
dialysate
blood
dialysate
solutes
semipermeable membrane
semipermeable membrane
blood
diffusion


Hemofiltration
blood
filtrate
blood
filtrate
positive hydrostatic pressure
negative hydrostatic pressure
Water and solutes
semipermeable membrane
semipermeable membrane
blood
convection

ULTRAFILTRATION

- It contains a semi permeable membrane that permits passage of water and electrolytes out of blood.
- The semi permeable membrane is manufactured in hollow fiber configuration.
- The hollow fibers are between 180 –200µm in diameter and the pores of microporous membrane are between 5 –10 nm.

- The rate of fluid depends on,
- ***Membrane permeability***

- ***Blood Flow***
- ***Transmembranepressure***
- ***Hematocrit.***

ADVANTAGES OF ULTRAFILTRATION

- ***Ultrafiltration removes excess fluids***
- Increased Hemocrit
- Decreased lung waters
- Decreased tissue edema
- Improves patient’s hemodynamics
- Improves cardiac contractility and oxygenation.
- Conserve platelets and coagulation factors that improve perioperative hemostasis.
- Conserve albumin.
- Reduces post operative ventilator support.

DISADVANTAGES

- Molecules up to a molecular mass of 20,000 Da

- At that time some heparin is removed and therefore, ***adequacy of heparinizations hould be checked.***

TYPES OF ULTRAFILTRATION

- Pre –Bypass ultrafiltration
- Conventional ultrafiltration
- Modified ultrafiltration
- Zero Balanced ultrafiltration

PRE BYPASS ULTRAFILTRATION

- ***Pre –Bypass Ultrafiltration:***
- The addition of bank blood to pump prime may elevate prime potassium, glucose, brandykinin, citrate, lactate levels. This may be deleterious especially to the neonate, whose blood volume is often less than the prime volume.

- The blood is then returned through cardiotomy reservoir.

- The advantages of the BUF is reduced cardiac impairment & pulmonary dysfunction.


Pre - By Pass
filter

Disadvantage:

- This technique has been shown to reduce the level of bradykinin, factor XIII, high molecular weight kininogen.
- BP drop is seen at the initiation of CPB.

Correction:

- Final prime electrolyte levels should be measured after pre –bypass ultrafiltration, this is to avoid removal, addition of certain priming drugs (mannitol, buffers).

CONVENTIONAL ULTRAFILTRATION

Conventional Ultrafiltration:

- It refers to the practice of withdrawing blood from the patient through the venous reservoir during rewarming period when patient is on CPB, and passing it through the hemoconcentrator and pumping it back into the patient through venous reservoir.

Technical consideration for conventional ultrafiltration:

- Must have adequate volume in venous reservoir to safely remove ultrafiltrate.

- A level detector with automatic pump shut off should be used to prevent dangerously low reservoir volumes.

- The shut created by diverting arterial blood flow through the ultrafiltermust be managed appropriately.

MODIFIED ULTRAFILTRATION

Modified ultrafiltration:

- It refers to the practice of withdrawing blood from the patient through aortic cannula, after weaning from CPB and passing it through a hemoconcentrator and pumping it back into the patient through venous cannula.

Technical consideration for modified ultrafiltration:

- Delays protamine administration
- Air entrapment in AV –MUF mode caused by negative pressure generated in the arterial line.
- Patient temperature loss may occur during VV –MUF or when a heat exchanger is not used.
- Aggressive AV –MUF may result in carotid steal.
- Rate of MUF pump should be indexed to patient size (15 –30ml /kg /min).
- Concentration of heparin into the patient will occur.

ADVANTAGES OF MUF

- ***Decreased blood loss***

- ***Fewer blood transfusion***

- ***Increase in arterial blood pressure.***

- ***MUF seems to be most effective in pediatric patients. This is due to the disparity in ratio of the circuit and patient volume.***

DISADVANTAGES OF MUF

- Patient needs to remain cannulated for 10 –20 minutes after CPB termination and to maintain integrity of ECC, protamine should not be added to MUF.
- Air aspiration is the major concern. Because of the risk of air entering into arterial circuit. Antegrade flow should not be permitted once MUF is begun.
- Technically complex require prior planning.