NORTHWEST Kidney Centers

Continuous Renal Replacement Therapy Self-Learning Package

NORTHWEST Kidney Centers

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Introductory Information

PURPOSE

The RN will demonstrate knowledge of the theory and skill related to the nursing care of the patient receiving Continuous Renal Replacement Therapy.

LEARNING OBJECTIVES

Following the completion of the independent learning activities, the RN will be able to:

1. Understand the principles and goals of Continuous Renal Replacement Therapy.
2. Identify complications of CRRT.
3. Perform appropriate exit site care.
4. Perform CRRT (CVVH, CVVHD, CVVHDF, SCUF using the Gambro PrismaFlex™).
5. Identify appropriate components to be documented about CRRT regimen.

REQUIREMENTS FOR COMPETENCY

The RN will:

1. Perform the following learning activities via independent study:
   a) Review the learning module for Continuous Renal Replacement Therapy (CRRT);
   b) Review Clinical Policy and Procedures for CRRT; and
   c) Review the supplementary readings and video related to this policy/procedure

2. Attend a one-day training session conducted by the Hospital Services Educator.
   a) The Charges Nurses will coordinate clinical sessions for hands-on patient care and CRRT competency checklist.
3. Successfully complete the CRRT Competency Skills checklists under the supervision of a certified RN.

Supplementary Resources (available through the Hospital Services Educator):

- Counts, C. (2008). Continuous Renal Replacement Therapy. In American Nephrology Nurses Association, *Core Curriculum for Nephrology Nursing* (5th ed.) (pp. 231-278). New Jersey: ANNA

- CD/DVD Tutorial: *"PrismaFlex"* produced by the Gambro Corporation

Continuous Renal Replacement Therapy (CRRT) History and Definition

Historically renal dialysis was first described by Thomas Graham in 1854. It wasn't until 1960 that dialysis became an option for the treatment of human renal failure. Since then there has been a lot of development with regards to the types of membrane materials used and vascular assess required.

Kolff Rotating Drum Dialysis Machine 1943

Definition: "Any extracorporeal blood product therapy intended to substitute for impaired renal function over an extended period of time and applied for or aimed at being applied for 24 hours/day."

Commonly called "CRRT", it performs the functions of the human kidney externally to the body.

CRRT can be both VenoVenous (VV) access or ArterioVenous (AV) access. The most common is VV access. There are many different types –

- SCUF – Slow Continuous UltraFiltration
- CVVH – Continuous VenoVenous HemoFiltration
- CVVHD – Continuous VenoVenous HemoDialysis
- CVVHDF – Continuous VenoVenous HemoDiaFiltration

When do we dialyze?
Chronic or acute renal failure.
Pre renal transplant due to genetic abnormalities or from disease processes.
For rapid removal of septic mediators or drugs.
Correction of electrolyte and acid/base disturbances

How does it work?

- Process by which solutes move passively down their concentration gradients, from one fluid compartment into the other (either blood or dialysate).
- Urea, Creatinine and Potassium move from the blood to the dialysate fluid.
- Calcium, Bicarbonate and other solutes move from the dialysate to the blood.
- The dialysate creates a "countercurrent" to the blood flow, maximizing the concentration gradient between the compartments, which in turn maximizes the rate of solute removal

What are we trying to achieve?

- Waste removal
- Electrolyte balance
- Fluid balance
- Acid – base balance
- Removal of septic mediators and/or drugs

Terms

Solution – A solid (e.g. glucose) can be dissolved in a liquid (e.g. water) and this forms a solution.

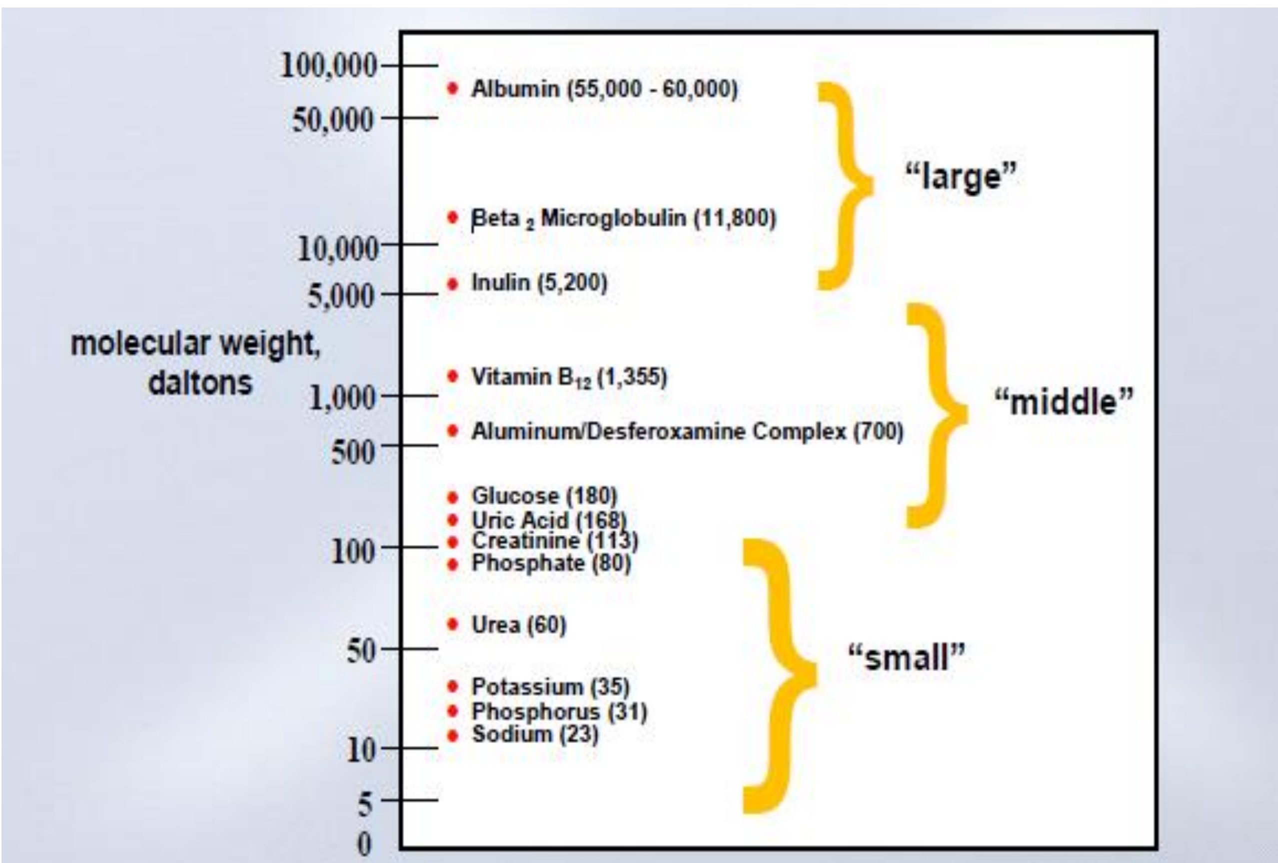
These ingredients are called the *solute* (solid) and the *solvent* (liquid).

They can be simple or very complex like our blood plasma, where water acts as a solvent for a mixture of solutes

The transport of a molecule through a membrane is governed primarily by its molecular weight.

Generally, the more a molecule weighs, the larger it is in size and the more resistant it is to transport. The chart below gives an indication of relative molecular weights for some of the common molecules we are concerned with in CRRT.

Molecular weights are measured in units called Daltons.



Osmosis is –

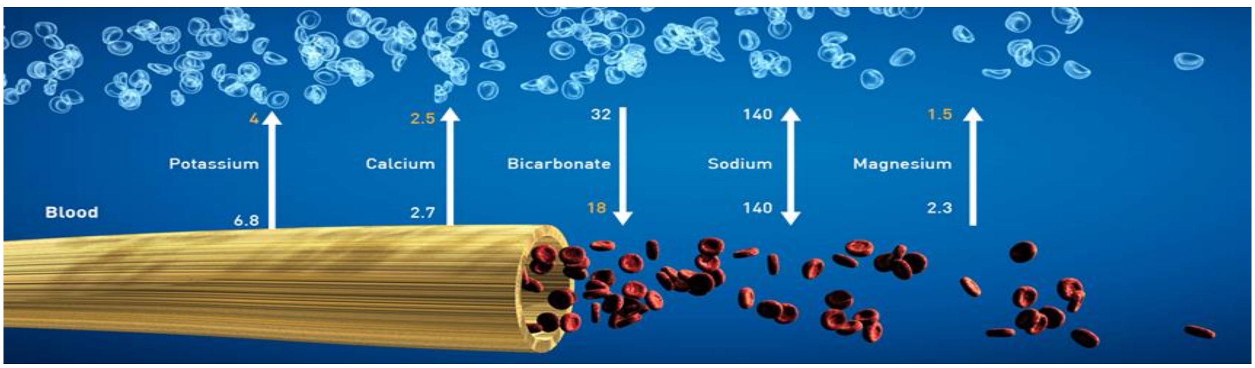
- The movement of a pure solvent such as water, through a differentially permeable membrane, from a solution that has a *lower* solute (particle) concentration to one that has a *higher* solute concentration.
- The rate of osmosis depends on the concentration of solute, the temperature of the solution, the electrical charge of the solute and the difference between the osmotic pressures exerted by the solutions. Movement across the membrane continues until the concentrations of the solutions equalize.

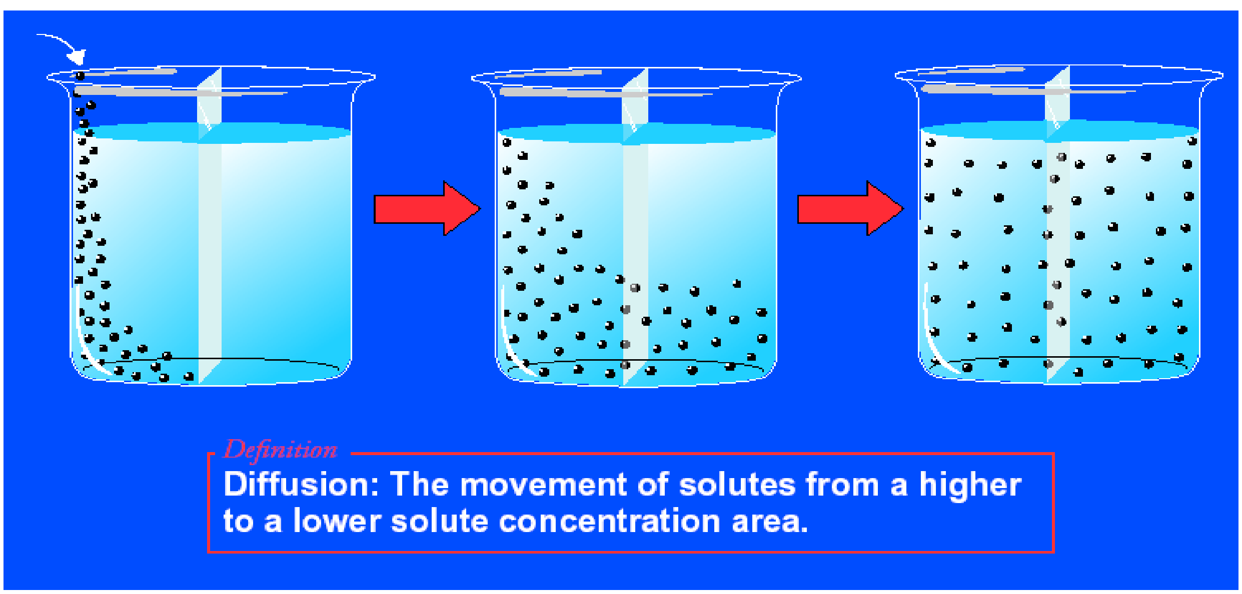
Diffusion is –

- the movement of solutes from a high to a low solute concentration across a semi-permeable membrane
- a concentration gradient is necessary for diffusion to occur
- it removes all small molecules
- the rate of diffusion is dependent on;
    - surface area of filter
    - ratio of dialysate flow to blood flow
    - size of the molecules

Diffusion = Hemodialysis

The movement of solutes only from an area of higher concentration to an area of lower concentration



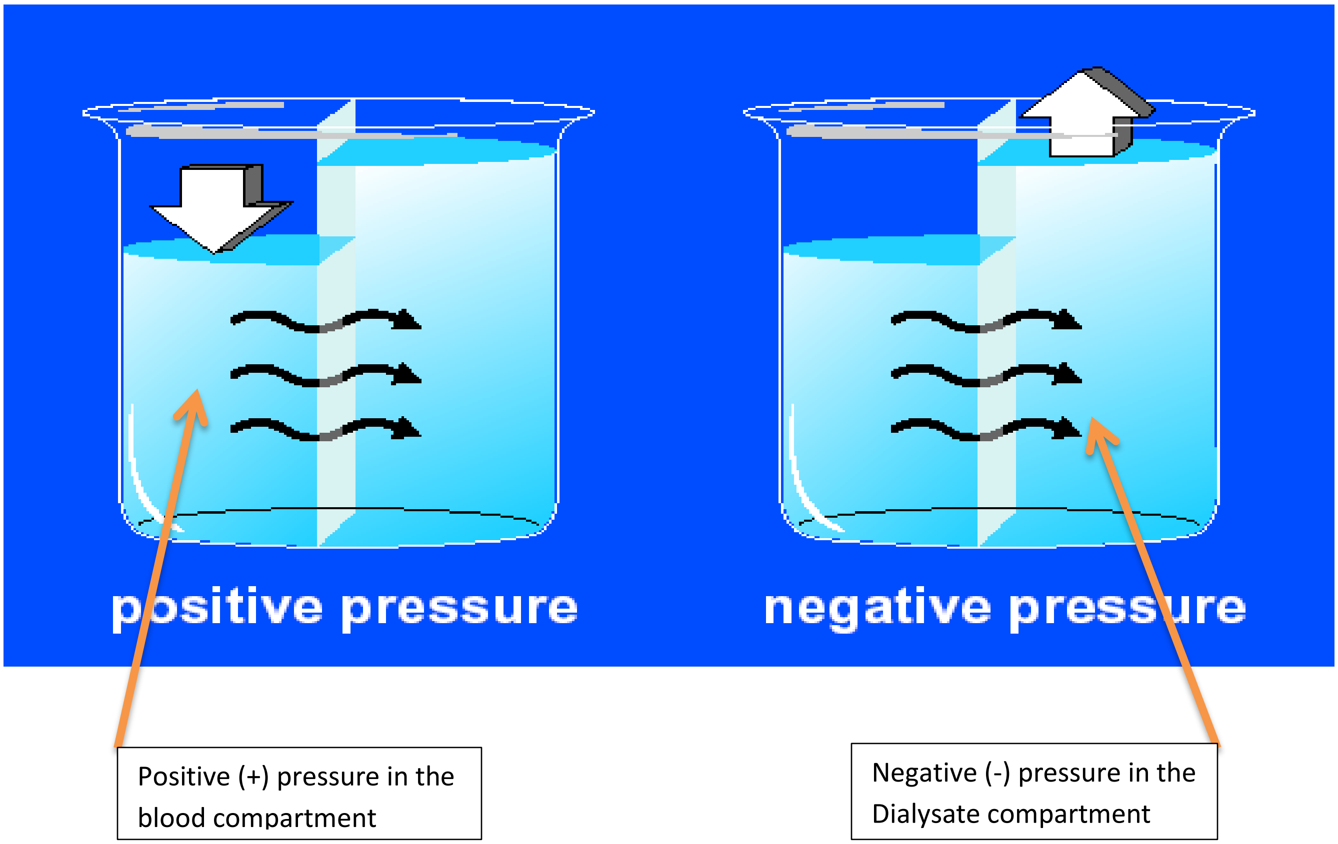


Ultrafiltration is –

- The movement of fluid through a membrane caused by a pressure gradient (hydrostatic or osmotic pressure).

Ultrafiltration= Fluid Removal

The forced movement of fluid

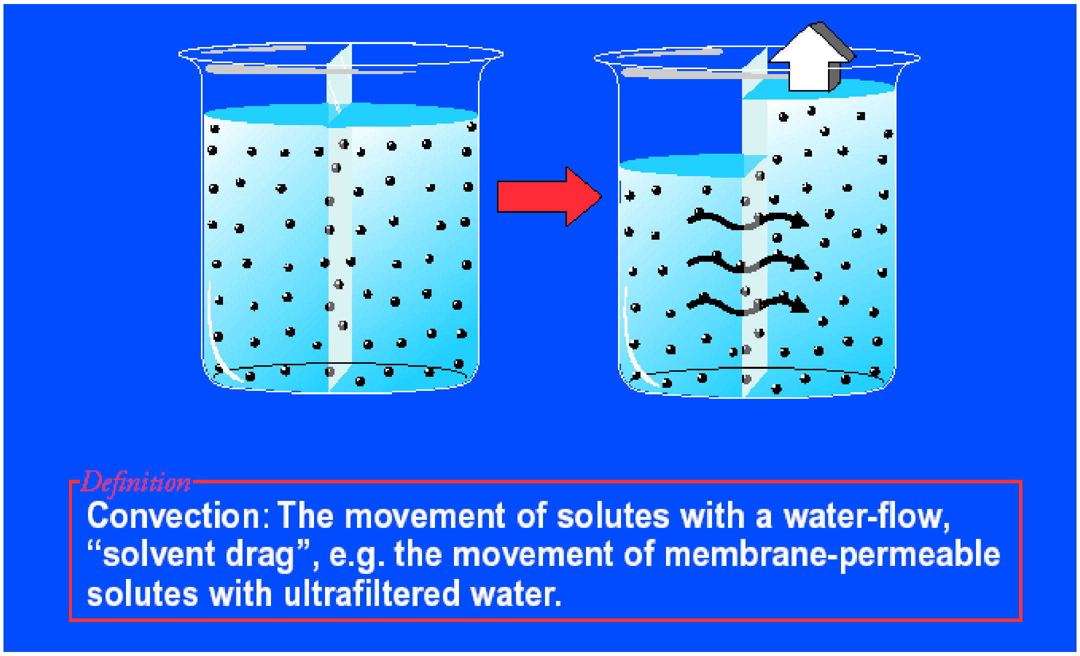


Convection is –

- the drag of solutes across a membrane during osmosis or ultrafiltration
- it is used for removal of middle and large molecules
- the greater the amount of fluid that moves, the greater the solute loss

Convection "Solute drag"= hemofiltration

The forced movement of fluid with dissolved solutes
(the fluid will drag the solutes)



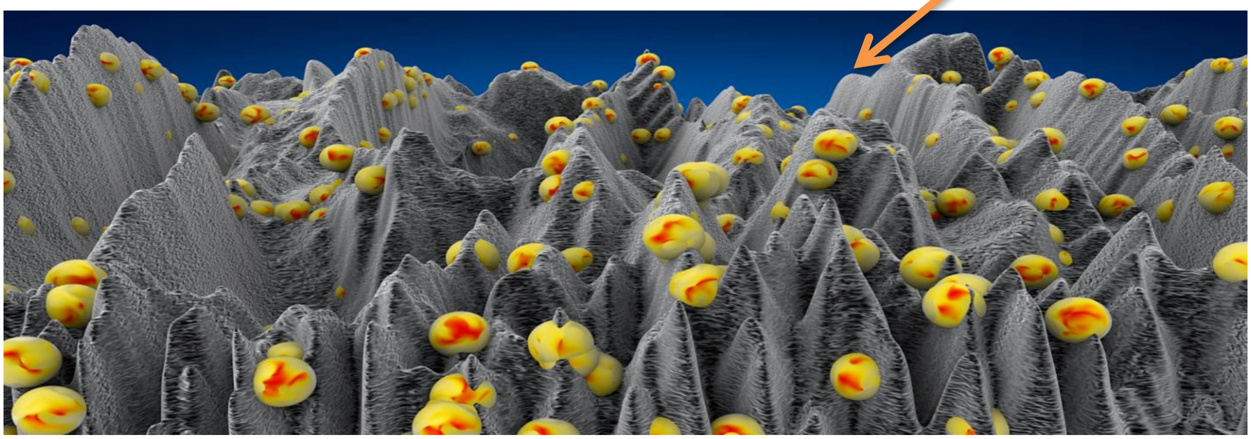
Adsorption occurs –

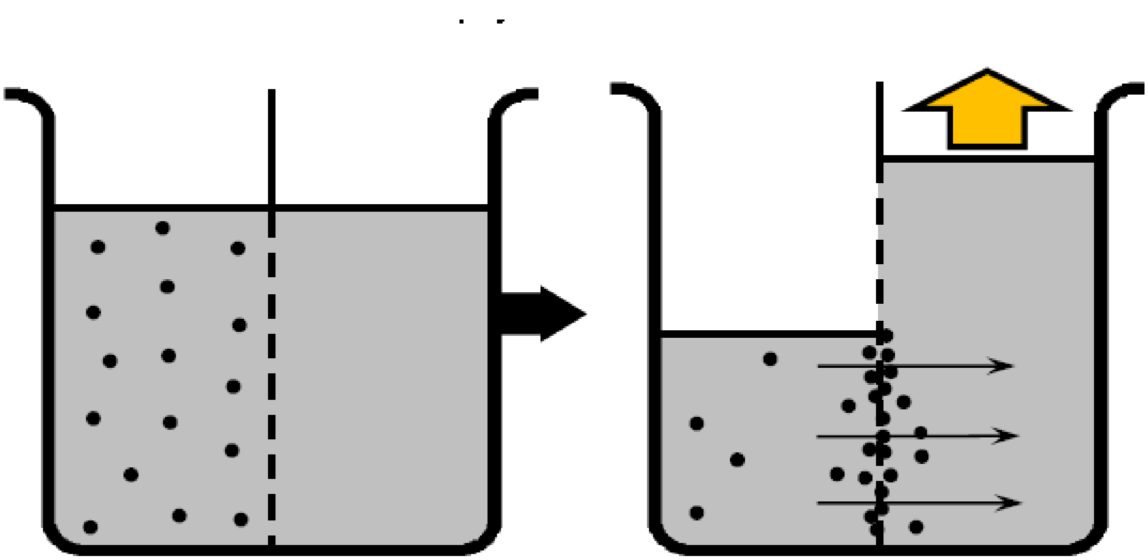
- When the molecules (solutes) adhere to the surface or interior of the membrane.
- With the movement of fluid across the membrane, if no fluid is moving then adsorption cannot occur.
- *in 2 manners:*
  - Surface adsorption where the molecules are too large to permeate and migrate through the membrane; however they can adhere to the membrane.
  - Bulk adsorption occurs within the whole membrane where molecules can permeate it.

Molecules that can be effectively adsorbed include:

- B2 microglobulin
- Cytokines
- Coagulation factors
- Anaphylatoxins

Solutes stick to the Fibers



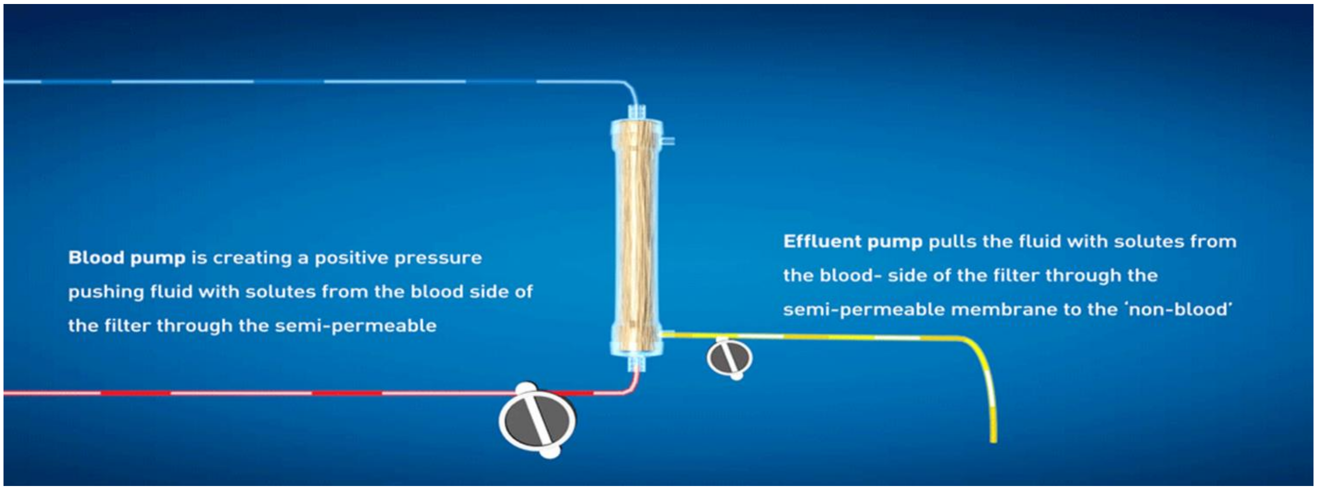


Mechanism of Dialysis

Dialysis therapy uses the mechanisms of ultrafiltration, hemofiltration and hemodialysis. The different modes utilize a selection of one or more of these mechanisms.

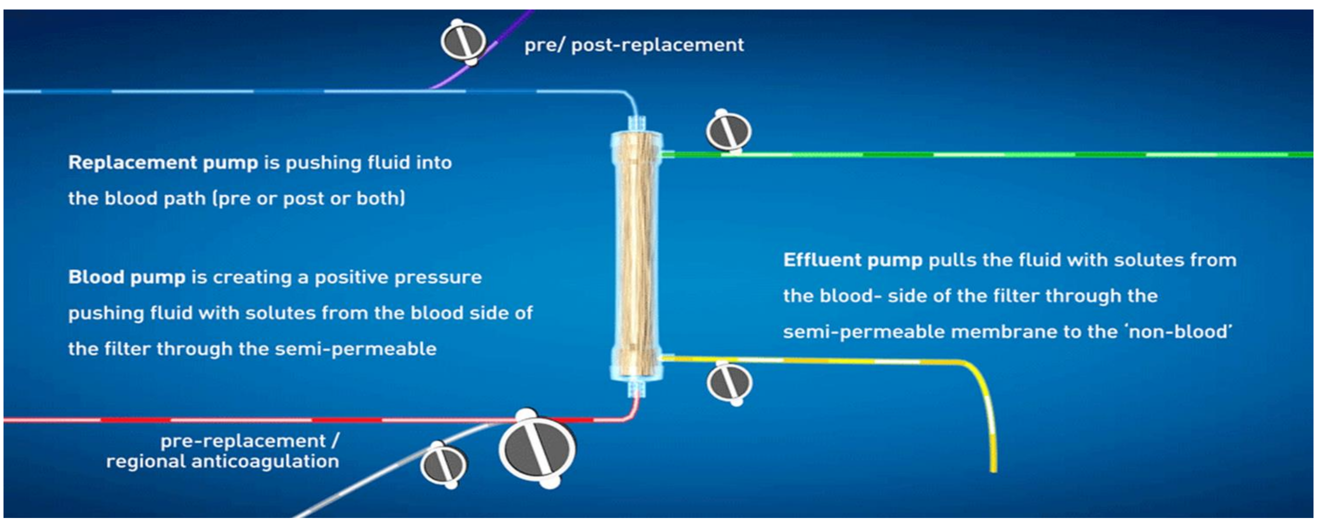
Ultrafiltration

Plasma water with solutes is drawn from the patient's blood across the semipermeable membrane in the filter. The effluent pump controls the ultrafiltration rate automatically according to the set flow rates.



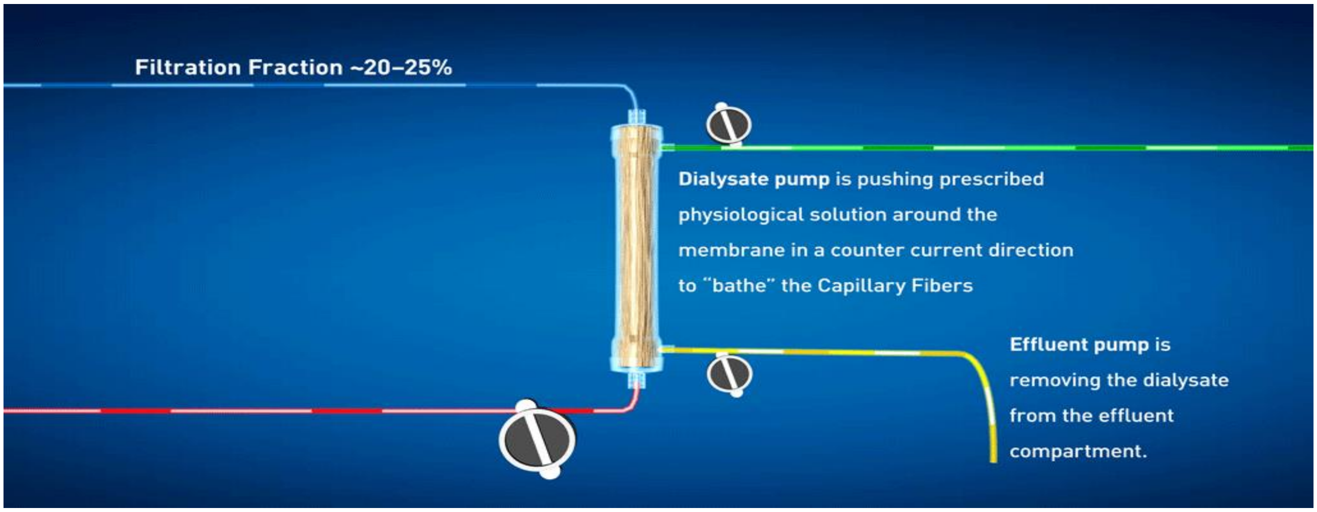
Hemofiltration

Plasma water with solutes is drawn from the patient's blood across the semi-permeable membrane by means of ultrafiltration. A replacement solution is simultaneously infused into the blood flow path. The replacement solution replaces some or all of the water removed, as well as the desired solutes. Unwanted solutes are not replaced, thus their concentration decreases in the patient's blood. Solute removal is achieved by convection (solvent drag across the membrane).



Hemodialysis

Unwanted solutes pass from the patient's blood across the semi-permeable membrane and into the dialysate which is flowing in the opposite direction through the fluid compartment of the filter. The concentration of unwanted solutes is lower in the dialysate than in the blood, causing the solutes to diffuse from an area of greater concentration to an area of lower concentration. Therefore, solute clearance is achieved by diffusion.



HemoDiaFiltration

In HemoDiaFiltration, both hemodialysis and hemofiltration are used. Solute removal occurs by convection and diffusion. Fluid is removed by ultrafiltration.

Dialysate fluid is pumped through the fluid compartment of the filter. At the same time, the effluent pump controls the ultrafiltration rate. A replacement solution is infused into the blood flow path either before or after the filter – (pre or post dilution). An equivalent amount of fluid is withdrawn via the effluent pump thereby maintaining a neutral balance.

Manipulation of the principles of dialysis

Diffusion is increased by:

- Increasing the rate of the dialysate flow
- Increasing the rate of blood flow
- Using counter current flow
- Composition of dialysate fluid to increase the concentration gradient
- Increasing the surface area of the membrane

Diffusion is decreased by:

- Decreasing the rate of the dialysate flow
- Decreasing the blood flow rate
- Dilution of the blood before the filter (pre-dilution with replacement solution)
- Decreasing the area of the membrane

Ultrafiltration and Convection are increased by:

- An increase in positive pressure on the blood side of the circuit. This can be caused by an increase in blood flow or an increase in the flow of pre-dilution replacement fluid
- An increase in negative pressure on the ultrafiltrate side of the membrane by increasing the rate of the effluent pump.

Ultrafiltration and convection are decreased by:

- A decrease in the positive pressure on the blood side of the circuit. This can be due to either a decrease in blood flow rate or a decrease in the rate of pre-dilution replacement fluid
- A decrease in negative pressure on the ultrafiltrate side caused by a decrease in the flow rate of the effluent pump.

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**** Dialysate + Replacement + PBP cannot exceed 8000 ml/hr***

**** Maximum Replacement rate will decrease if delivering 100 % postdilution***

CVVH, CVVHD, CVVHDF will always require a Calcium Drip

Therapy	Transport Mechanism	Molecule Size	Flex Pumps	Transport Fluid	Maximum Pump Rates					Max. Pt. Fluid Removal Rate	Patient Applications
					Dialysate	Replace	PBP	Effluent	Blood		
SCUF	Ultrafiltration	None	Blood Effluent PBP ?	None	0	0	1000 ml/hr	3000 ml/hr	450 ml/min	2000 ml/hr	Fluid Overload CHF
CVVH	Convection	Small Middle Large	Blood Effluent Replacement PBP ?	Replacement fluid	0	8000 ml/hr *	8000 ml/hr *	10,000 ml/hr	450 ml/min	2000 ml/hr	Fluid Overload CHF Acute Renal Failure Sepsis Crush Syndrome
CVVHD	Diffusion	Small	Blood Effluent Dialysate PBP ?	Dialysate	8000 ml/hr *	0	8000 ml/hr *	10,000 ml/hr	450 ml/min	2000 ml/hr	ARF Metabolic Acidosis Hypercatabolism Electrolyte Imbalances
CVVHDF	Convection & Diffusion	Small Middle Large	Blood Effluent Replacement Dialysate PBP ?	Replacement fluid Dialysate	8000 ml/hr *	8000 ml/hr *	8000 ml/hr *	10,000 ml/hr	450 ml/min	2000 ml/hr	Fluid Overload CHF ARF SIRS Sepsis Crush Syndrome Rhabdomyolysis

How Pre or Post Replacement works!

Pre Replacement

- Pre-filter replacement solution will deliver into the blood flow at set rate.
- Blood will be diluted ↓Hct.

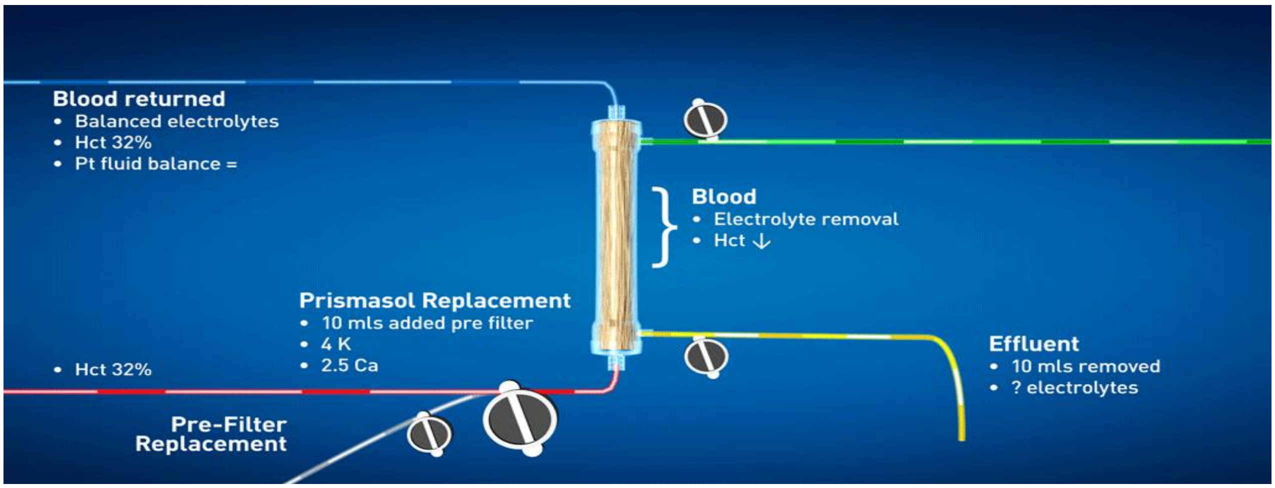
The replacement "fluid volume" will be removed by the effluent pump

Post Replacement

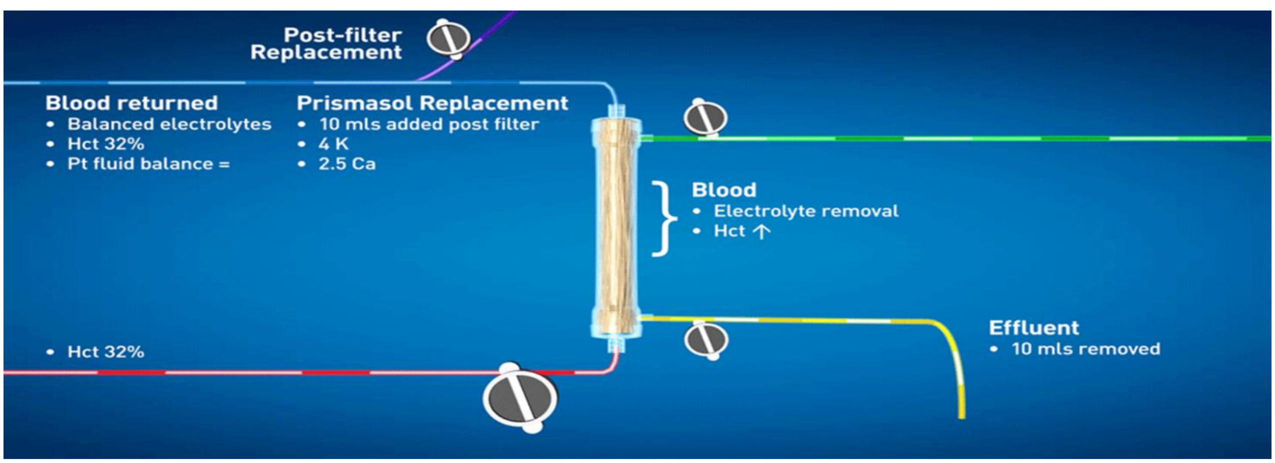
- The replacement "fluid volume" will be removed by the effluent pump.
- Blood will be concentrated ↑Hct.

Post-filter replacement solution will deliver replacement solution to "replace" the removed "volume" and replenish lost electrolytes

Pre-dilution of the filter is useful because it decreases blood viscosity and can therefore prolong the life of the filter. It also increases solute removal via convection as more fluid is moving across the membrane.



Post dilution benefits are increased clearance due no pre-dilution of blood, however a higher FF% results creating a higher risk of protein caking and clotting in the filter. Post dilution will require less replacement fluid to achieve an equivalent clearance (dose).

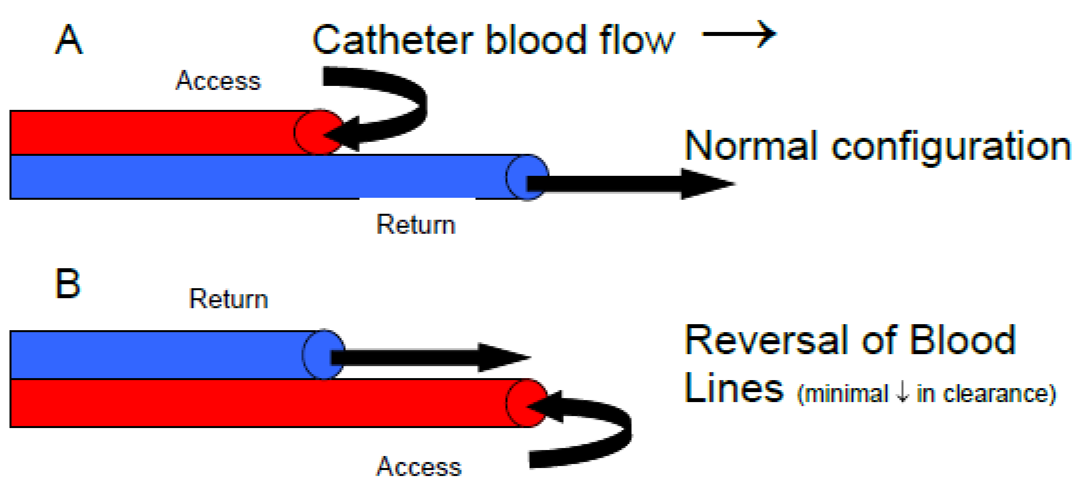


What do you need?

- A filter or membrane through which the blood can pass.
- An Access line to pull the blood out of the patient.
- A Return line to return the blood to the patient.
- An effluent bag to collect the waste.
- Various fluid lines, as the types of dialysis become more complex more lines are added:
    - Anticoagulation
    - Dialysate fluid
        - Has the characteristics of:
            - Driving diffusion transport
            - Contains electrolytes at physiological levels
            - Components can be adjusted to meet patient needs (mainly the potassium and bicarbonate concentration).
    - Replacement fluid
        - Has the same characteristic as the dialysate fluid used, it can be pre or post replacement fluid.
        - Pre Blood Pump (PBP) – this fluid is specific to the Prismaflex machine. It functions as a pre-dilutional fluid that connects into the access line close to the patient. This allows for both a pre-dilution fluid as well as a post dilution replacement fluid.

The "Access/Return Line" aka Dialysis Catheter

Fluid is drawn in through the access side (red side) of the vascath, circulated through the filter and then returned to the patient on the return side of the vascath (blue side). A vascath can be inserted into the internal jugular vein, subclavian vein or the femoral vein. A shorter length (15cm) is used for IJ or SC sites, while a longer (20cm) length is used for femoral insertions.

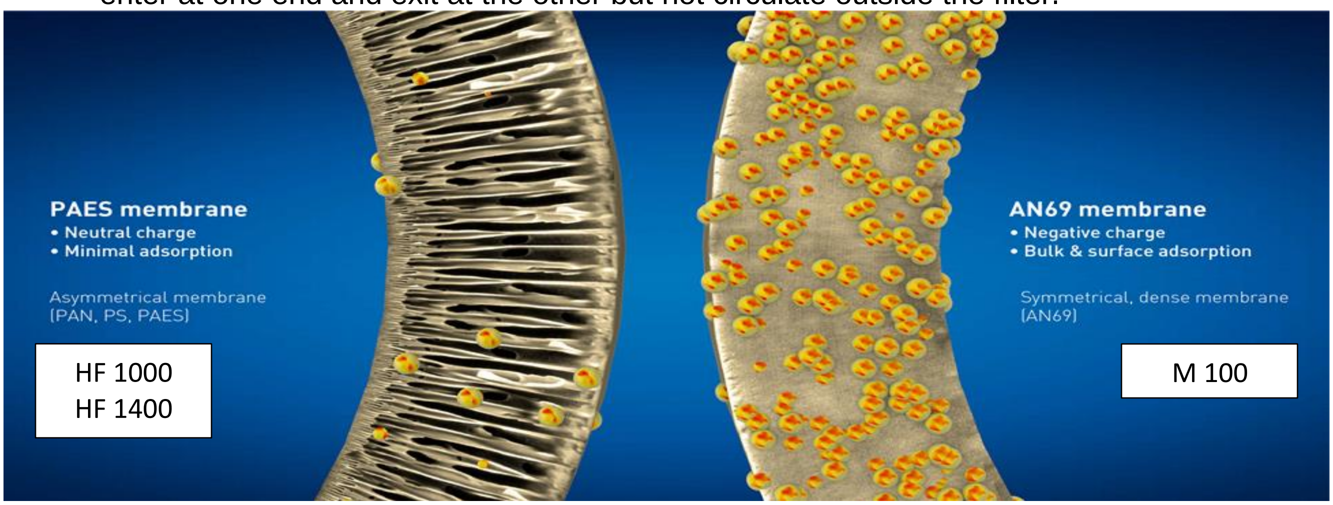


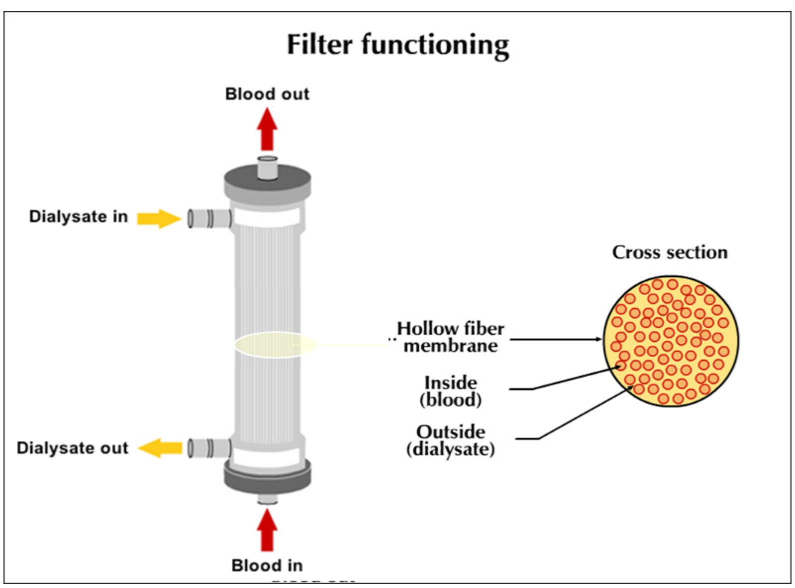
The fluids

- The composition of the replacement, dialysate and
- Pre-dilutional fluid is a standard solution with a predetermined concentration of base (usually bicarbonate) and ions.
- We can customize the solution by adding potassium or bicarb.
- There are fluid bags that contain lactate as a base or which contain low or no lactate in the fluid.

The Filter

- Is made of many thousands of small hollow fibers (8,000-10,000).
- Each fiber is manufactured with small pores, through which water and its contained solutes pass.
- The fibers are bundled together in a tube.
- They are enclosed in the tube. The ends of the fibers remain open, enabling blood to enter at one end and exit at the other but not circulate outside the filter.





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The Machine

- Consist of a number of pump heads – blood, dialysate, effluent, replacement, and PBP.
- Have an air detector in the return line and a de-aeration chamber
- They normally have pressure sensors (pods) in the lines
    - access, filter, effluent, return.
- They measure Transmembrane Pressure (TMP) and Pressure Drop (continuously)

The Prismaflex machines have a prompt screen which provides step by step instructions for priming, attaching and/or removing lines. Hence a detailed protocol has not been included in this learning package. However some general guidelines, a dictionary of related terminology and lists of the required equipment have been included.

General Guidelines

Prior to the commencement of CRRT it is important to check that there is adequate stock of all necessary items such as:

- Dialysis circuits
- Fluid bags (containing lactate or low lactate solutions)
- Blood warmer
- Potassium
- Calcium –needed whenever doing CVVH, CVVHD, CVVHDF
- Heparin

A clean technique is used while priming and preparing the filter and lines.

An aseptic technique is used to connect lines to the catheter or when accessing the catheter for any reason including dressings.

Standardized orders have been developed for the Heparin, Calcium and Citrate Infusion and the flow rates.

The Fluid Removal rate controls the desired fluid balance. The patient’s intake needs to be taken into account when setting this rate. The commencement fluid removal rate is set by Nephrologist. This amount is above the removal of the replacement fluid + dialysate fluid and PBP fluid that is going through the filter.

Emptying the effluent bag should only be attended when so directed by the machine prompt screen. Emptying it too soon will disrupt the machine’s fluid balance calculations.

General Guidelines Contd.

The replacement / dialysate / PBP bags may be changed at any time during treatment. To achieve this you are required to go into the main menu and select “change bags” and follow the prompts on the screen.

When it is time to change the first effluent bag a new one is opened to replace it. For subsequent changes these two bags are alternated. (NB: The effluent is sterile and is draining away from the patient so this practice does not put the patient at risk.)

The scales are very sensitive and should not be in contact with anything that will disturb them, as this will alter the pump flow rates e.g.: do not hang the spare effluent bag on the side hooks because if it touches the scales it will disrupt the fluid balance.

Hourly observations include checking and documenting the flow rates; Access, Filter, Effluent, Return and TMP pressures; deaeration chamber fluid level.

When connecting the circuit to the catheter it is not necessary to expel the priming fluid first as the filter and lines only contain 90 - 120ml of fluid. Therefore, both the access and return lines are connected at the same time.

Alternative Anticoagulants Therapies

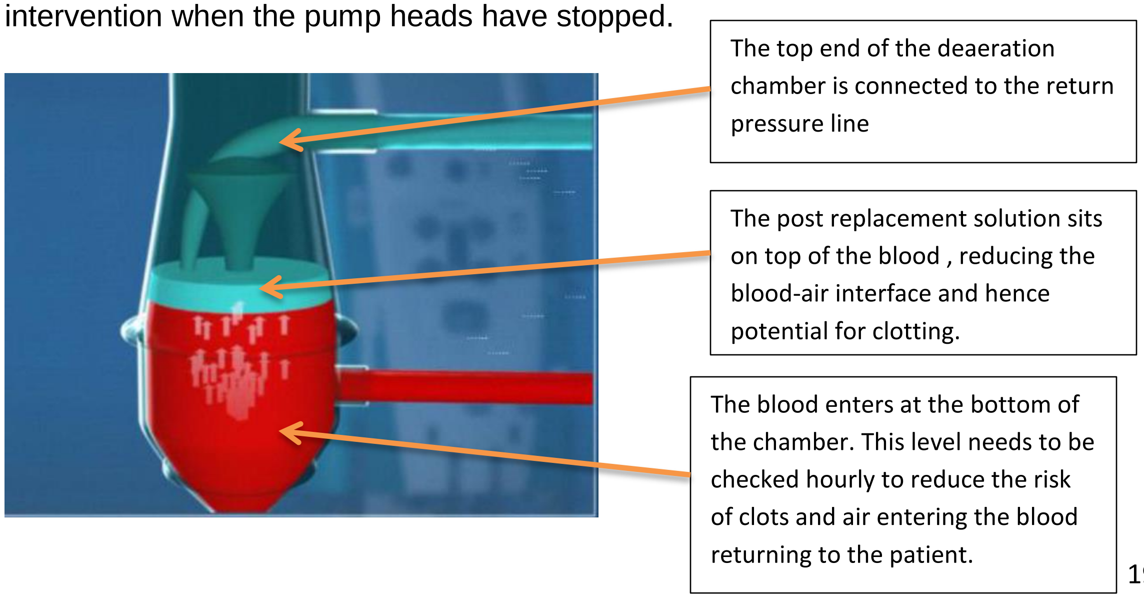
- Heparin
  - Inhibits Factor Xa, and this reduces thrombin and thrombus formations. It does this by inhibiting the normal clotting cascade determined by PTT or Facto Xa. <u>It does cause systemic anticoagulation</u>
- Citrate
  - Anticoagulants by chelation of ionized calcium. It is added pre-filter in the form of Acid **Citrate** Dextrose Solution (ACDA) and is neutralized by a post-filter infusion of calcium chloride. <u>It does not cause systemic anticoagulation</u>. It has excellent filter patency, lasting longer than full heparinization. **Always need Dialysate when using Citrate.**
- No anticoagulation at all.

The Prismaflex machines utilize the following modes:

- SCUF
- CVVH
- CVVHD
- CVVHDF

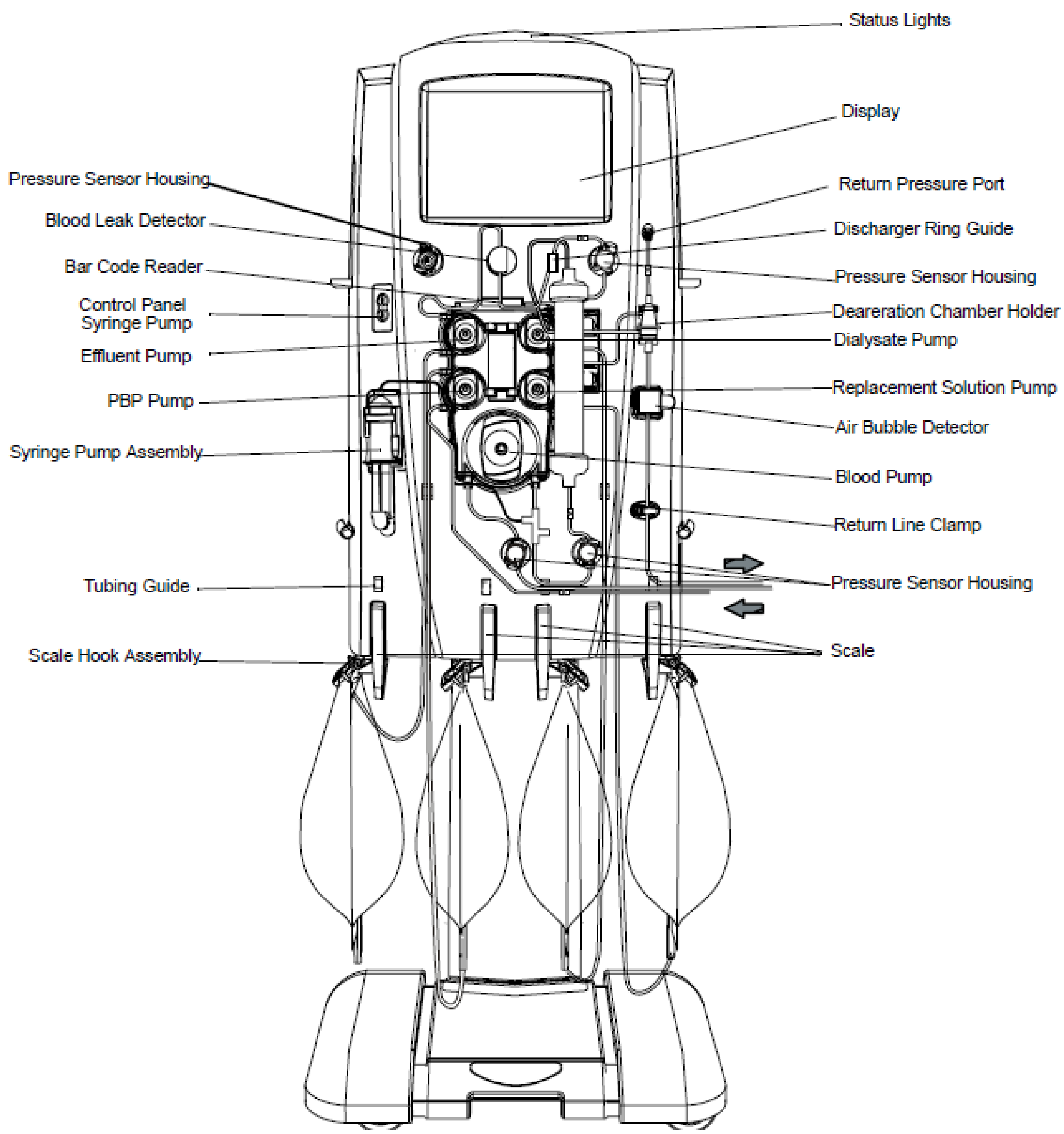
The Prismaflex features:

1. There are priming hooks on the sides of the machine to decrease any injuries with lifting the 5 liter bags of solution.
2. The solutions hang on removable hooks that slide in and out from under the machine for easy access. These slides need to be pushed in all the way back into place or the machine will malfunction and the scales will not be able to function correctly.
3. There is a ring discharger on the effluent line which provides an electrical connection to “ground” to minimize interference by the Prismaflex pumps with the patient’s electrocardiogram (ECG) recordings.
4. The screen is a touch screen and is designed with touch buttons that take you from one screen to another. During set up you are able to view diagrams that will show you exactly what and where lines are to be routed or hung.
5. There is a built in override mechanism, if any pressure is exceeded, the machine stops until the pressures are back to normal ranges and then it will *auto start*.
6. There are also only 3 pressure pods as the pressure register for the return line is measured via a pressure line and not a pod.
7. The effluent pressure pod is not always primed during priming but once the machine does the pressure pod PRIME TEST it fills this up.
8. There is a deaeration chamber on the return line that allows post replacement fluid to enter the top. This gives the operator more flexibility to troubleshoot. It also decreases the risk of air being returned to the patient as the air will get caught in the chamber. There is a faint marking on the chamber that indicates the optimal level of blood in the chamber. The replacement fluid level sits above this. This level can be adjusted at any time during treatment by accessing the “adjust chamber” screen. It is important to check the level in the chamber every hour and also after any intervention when the pump heads have stopped.




5th pod
Effluent pump
Pre-Blood pump
Access pod
Return pod
Effluent pod
Dialysate pump
Replacement pump
Filter pod


Rinse back Handle



Status Lights
Display
Pressure Sensor Housing
Blood Leak Detector
Bar Code Reader
Control Panel
Syringe Pump
Effluent Pump
PBP Pump
Syringe Pump Assembly
Return Pressure Port
Discharger Ring Guide
Pressure Sensor Housing
Deareration Chamber Holder
Dialysate Pump
Replacement Solution Pump
Air Bubble Detector
Blood Pump
Return Line Clamp
Pressure Sensor Housing
Tubing Guide
Scale Hook Assembly
Scale

The Prismaflex has additional lines:

1. Pre Blood Pump, PBP (White Line).

    a. It joins the access line close to the patient. This line is used for Citrate infusions. This is set at a max flow rate of 300ml/hour.

2. The Dialysate Line (Green Line)

    a. This line still creates the counter current inside the filter. The usual solutions that are used are a bicarbonate based solution. The dialysate line has no direct contact between the blood and dialysate solution. The typical flow rate for this is set at 1000-2000ml/hour on the Prismaflex.

3. The Replacement Line (Purple line)

    a. On the Prismaflex the replacement line can be either pre or post dilution. We tend to use it as pre and *post* dilution fluid during CVVH as we run the “Dialysate” as a post dilution fluid. On the Prismaflex this post filter line joins the return line at the deaeration chamber:

        i. Allows for a decrease in blood air interface and therefore decreases the risk of clotting in the deaeration chamber.

4. The effluent Line remains the same (Yellow line).

    a. The Prismaflex is capable of running at much higher rates with all fluids and so allows for more effective CRRT treatment.

    b. It is also possible to admit the patient details including their weight into the machine so that you are able to get measurements in ml/kg.

5. Alarms. The alarm colors are as follow:,

6. Green light if all is running correctly,
7. Orange if it is a non-urgent alarm (bag change due- the blood pump heads will continue to turn during this alarm)
8. Red if there is serious problem. (the blood pump heads will stop if this alarm is activated).
9. End treatment / Change set: Once the „stop‟ button is pressed on the Prismaflex you will be given 3 options (Recirculation / end treatment / change set), follow the onscreen instructions to return blood, disconnect or change the set.
10. Retuning the blood. The patient’s blood should be returned whenever possible. This is a clinically based decision, but generally if the machine gives you the option of returning the blood then you can. If there are visible clots in the circuit then it might be safer not to, but you can always start returning the blood and stop immediately any clots are seen.

Slow Continuous Ultra Filtration (SCUF)

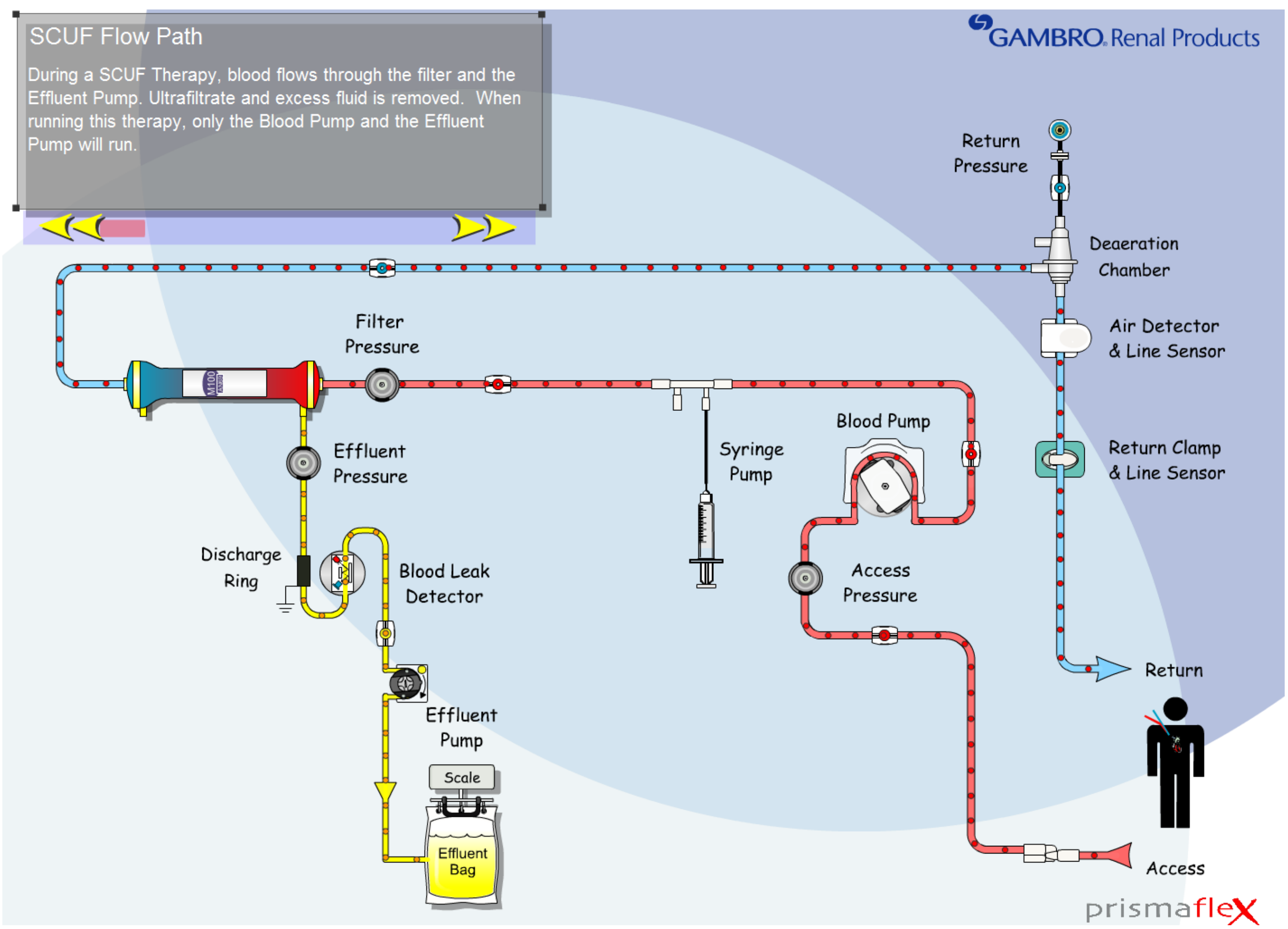
This is the process of slow fluid removal across a semipermeable membrane. Because the ultrafiltrate will have a similar composition to that of blood, the clearance of solutes is not as effective as dialysis. The blood is taken out through the access line and passes through the filter and solutes and fluid are removed and the blood is returned to the patient. Anticoagulation is usually required.

<u>Primary therapeutic goal:</u>

- Safe management of fluid removal
- Large fluid removal via ultrafiltration

Note that when using this therapy, significant amounts of fluid are removed from the patient. <u>No dialysate or replacement fluid is used to increase solute removal</u>. Ultrafiltration can be adjusted to cause dramatic fluid shifts. The blood flow rates seem low compared with standard intermittent hemodialysis blood flow rates … this is because the therapy is being delivered continuously.

REMEMBER: This therapy is best suited to severely hypervolemic patients (i.e. heart failure, post open-heart surgery, post resuscitation, etc.).



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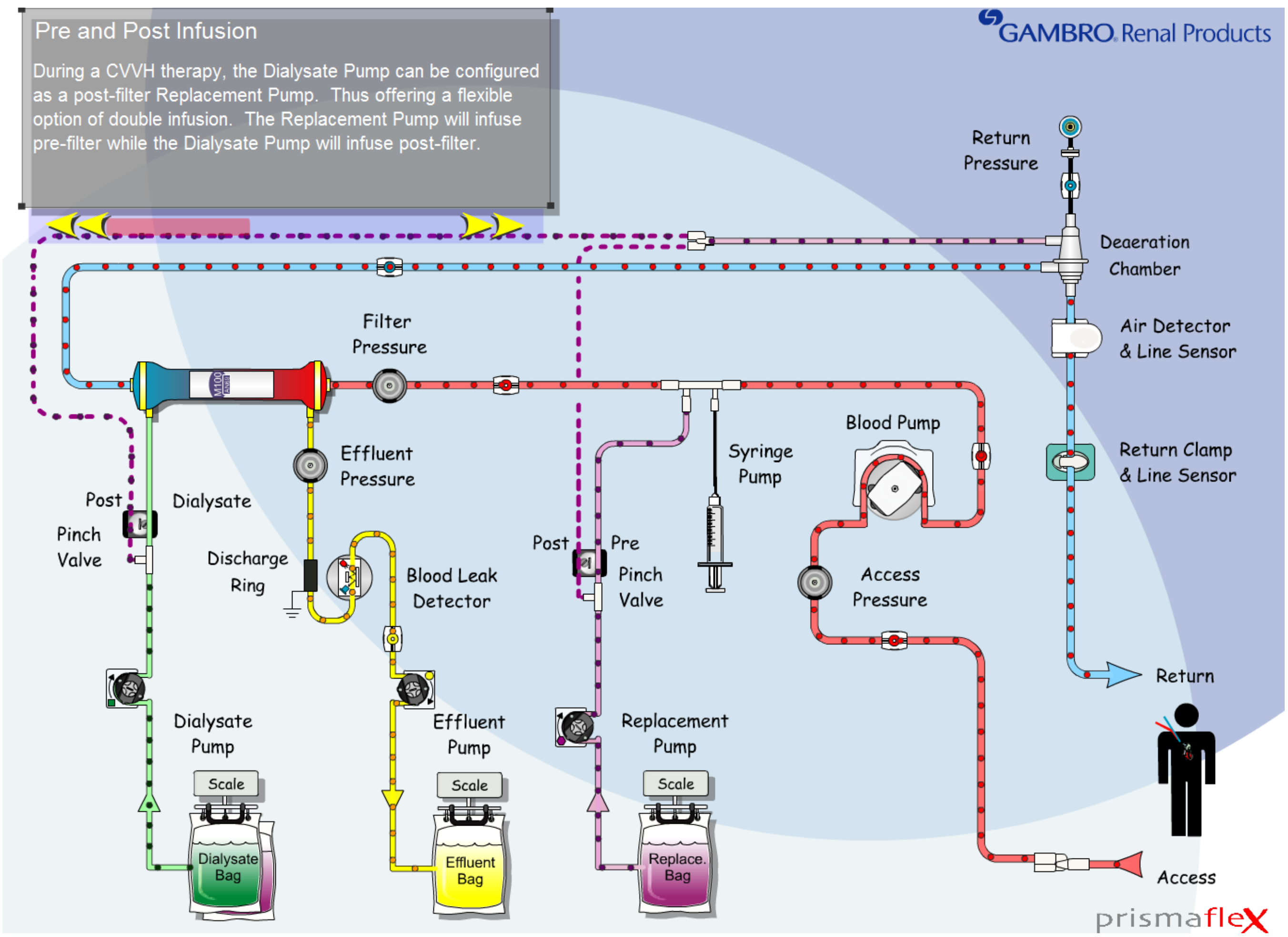
Continuous VenoVenous Hemofiltration (CVVH)

Hemofiltration uses the same process as SCUF to remove typically up to 2-3 liters per hour. This rate of fluid removal will obviously result in hemodynamic instability and therefore requires the replacement of large amounts of fluid. **Requires replacement fluid!!!**
The fluid used to replace the ultrafiltration excess is usually commercially available replacement fluid.
To perform CVVH he blood is taken out through the access line and passes through the filter and solutes and fluid are removed and the blood is returned to the patient. On the Prismaflex has the ability to run replacement solution both pre and post filter.
Primary therapeutic goal:

- Safe management of fluid removal
- Large fluid removal via ultrafiltration
- Convection
- Adsorption.
- Treatment of patients with sepsis
- Large molecule removal

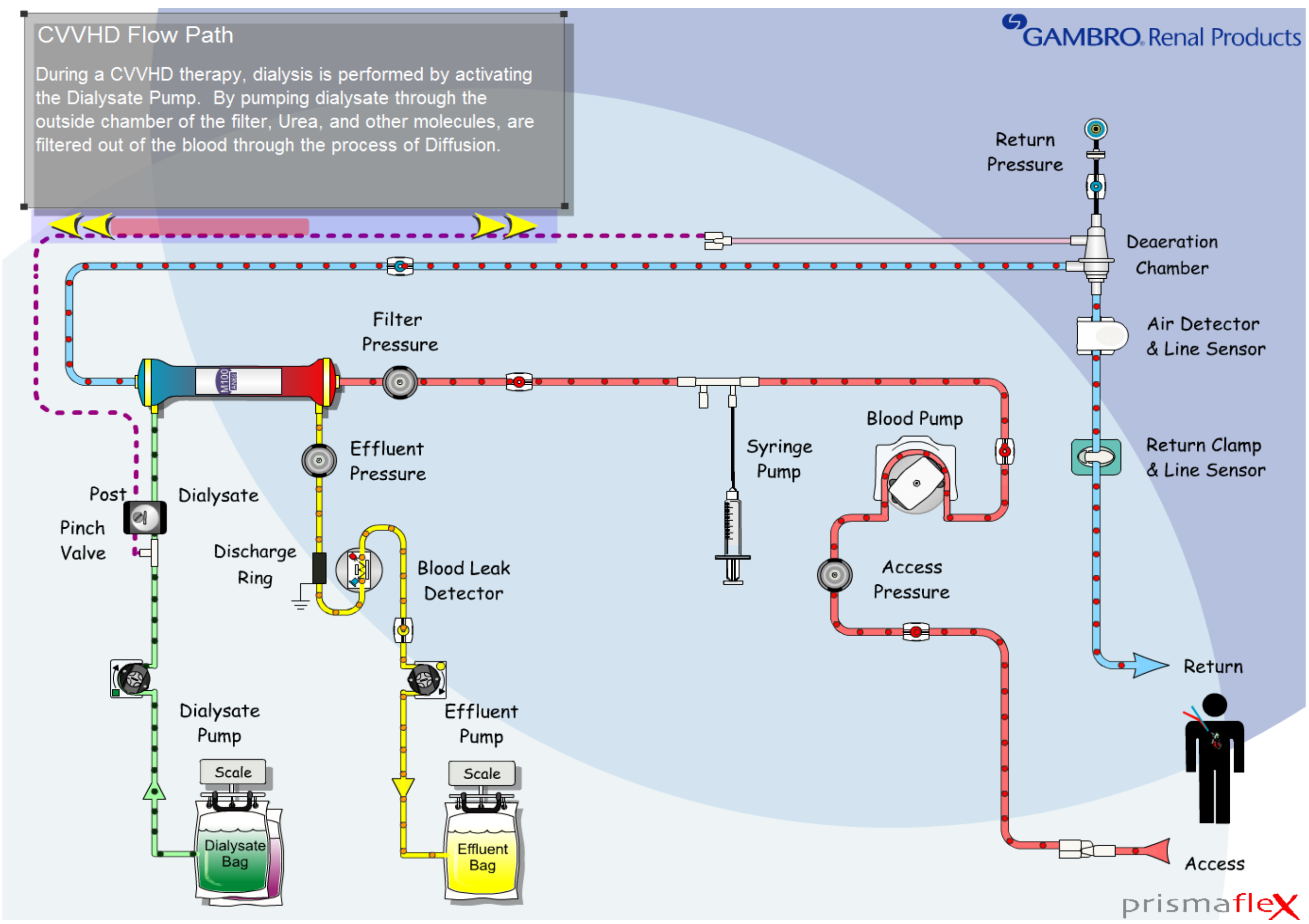


Continuous VenoVenous Hemofiltration (CVVHD)

In CVVHD a <u>dialysate solution</u> is passed counter current to the blood to encourage diffusion of solutes across the membrane. A dialysate flow rate of 12-15ml/min represents about 3% of normal dialysate flow during conventional hemodialysis. At this low rate the dialysate outflow is almost 100% saturated with urea. This means urea clearance is 12-15 ml/min. Ultrafiltration rate is kept low at 3-5 ml/min thus negating the need to administer replacement fluid. <u>**Requires dialysate fluid!!!**</u>

<u>Primary therapeutic goal:</u>

- Diffusion
- Safe management of fluid removal
- Small to moderate fluid removal via ultrafiltration
- Minimal adsorption.
- Treatment of patients with Acute Renal Failure (ARF) but without sepsis
- Small molecule removal



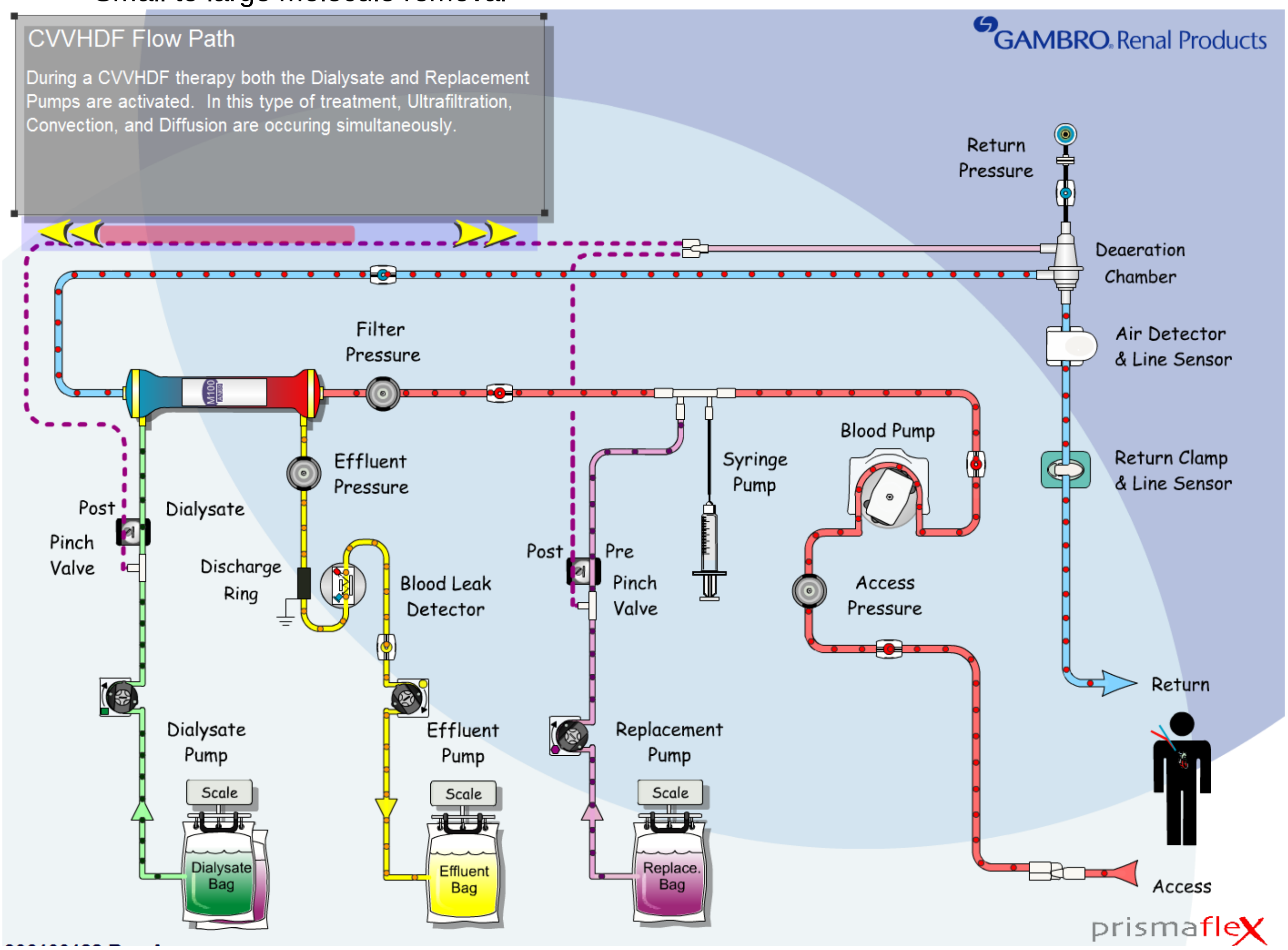
- Controlled fluid removal
- Slow correction of electrolyte and acid/base derangements
- Good small solute removal

Continuous VenoVenous Hemofiltration (CVVHDF)

In CVVHDF a dialysate solution is passed counter current to the blood to encourage diffusion of solutes across the membrane. A pre-filter replacement solution is also required to improve clearance rates and allow for convection to occur. **Requires dialysate and replacement fluid**

Primary therapeutic goal:

- Diffusion
- Convection
- Adsorption
- Safe management of fluid removal
- Small to large fluid removal via ultrafiltration
- Treatment for patients with ARF Multiple Organ Dysfunction Syndrome (MODS)
- Sepsis
- Small to large molecule removal



PUMP SET-UP and PREPARING OF ACCESS:

1. Gather equipment and ordered fluids
    a. Review the orders
    b. Page Nephrologist for any clarification or order inaccuracies.
    c. Notify pharmacy if solutions are incorrect
    d. Ensure ordered fluids are available
2. General Tips
    a. Do not skip ahead; set up as the Flex prompts you
    b. The Flex does not have a battery backup, and must remain plugged in
    c. Always plug into a red outlet
3. Turn machine on and select "new patient"
4. Load CRRT Set as instructed on the screen. No fluid can be on the scales at this time.
5. Prepare the lines and solutions as directed by the CRRT on-screen display.
    a. If the machine alarms "Missing Scale Component"—you will need to restart this setup—scale accuracy cannot be verified if the scale component is missing even if it is not missing—DO NOT OVERRIDE, THIS WILL LEAVE MACHINE IN YELLOW LIGHT MODE FOR ENTIRE TREATMENT.
6. Prime machine with ordered solutions.
    a. It is ok to prime with NS till the solutions arrive to help with time management—would need to start therapy then go to change bags to change the bags when they are available.
7. During this priming, gather supplies for access.
    a. Mask, gloves, gauze, chlorhexadine, NS syringe flushes, empty syringes, lab tubs if needed, blue pad.
8. Following the prime and "Self-Test", use "Manual Prime" to clear any air in the system.
    a. Selecting "Reprime" starts the entire prime process again and would require additional 1-2 liters depending on filter size.
    b. Also verify the Flex has passed all Self Tests as instructed on the screen.
9. Set excess fluid gain/loss limits
    a. 400 ml—standard for adults
    b. 100 ml—pediatric limit and patients less than 40kgs
10. Set Flow Rates as ordered
11. Prepare access
    a. Create aseptic field
    b. Clean hubs with chlorhexadine
    c. Connect empty syringe
    d. Aspirate 5 ml of blood for waste
        i. If doing blood culture save this blood for culture
    e. Obtain labs if needed
12. Connect the access and return lines to corresponding ports.
    a. **The Flex must be attached to the patient within 30 minutes of priming. If unable to initiate within first 30 minutes, will need to reprime**.
13. Press "Start" to initiate therapy.
14. Make note of the initial pressures on CRRT log sheet.

Troubleshooting

The interruption of the dialysis machine for any period of time will adversely affect the life of the circuit. Troubleshooting a dialysis machine is an on-going task. Dialysis runs more effectively if the operator has an understanding of how the machine works and functions. The nurse then has the ability to quickly and effectively correct malfunctions.

1. **WARNING ALARMS** (Red Light) Note: For safety, all warning alarms will cause the blood pump to stop and the return line clamp to engage, preventing the return of blood the patient.
   a. Access extremely negative/Return extremely positive
      i. Reposition the patient.
      ii. Ensure that none of the lines are kinked or clamped.
      iii. Swap the access and return lines.
      iv. Turn/rotate the temporary catheter within the vessel.
      v. Decrease blood flow rate
      vi. Assess pressure pods for proper placement and adjust if necessary

   b. Air in blood—indicates the air detector on the return line has sensed air in the blood line.
      i. Press "Mute"
      ii. Follow on screen directions
      iii. Open air detector and assess for air/foam.
      iv. Press  until return pressure is Negative (-1 to -150)
      v. Press "Release" clamp key
      vi. Press Adjust chamber key to adjust fluid level
      vii. Close air detector door
      viii. Press Continue
   c. Filter is Clotted
      i. Attempt to return blood if possible.
      ii. Press "Stop", then Press "Disconnect"
      iii. Clamp all lines and solution bags
      iv. Disconnect patient from circuit.
      v. Flush catheters and lock
      vi. Turn off machine and restart
         1. *Leave machine turned on and push to side (machine will not alarm in this state) if you are having the ICU RN disconnect patient—this will prevent any issues if machine is turned off with a set still loaded on it when it is restarted.*
   d. Blood Leak Detected—Blood has been detected.
      i. Press "OVERRIDE" to clear alarm.
      ii. Draw sample from effluent line and test for blood
      iii. Go to System Tools and press "Normalize BLD" if sample is Negative for blood.

1. If positive, end treatment and DO NOT RETURN blood.

iv. Verify Signal Value is 38,000 or greater. If below 38,000 move effluent line slightly up or down in the detector till signal value greater than 38,000.

v. Press START NORM. When complete, system will automatically return to Status screen.

2. **MALFUNCTION ALARMS:** (Red Light)
   a. Self-Test Failure (example: Code 1 Access) requires Pod Adjustment
      i. Press Mute
      ii. Press Stop
      iii. Use 2 blue clamps (chest tube clamps will work as well), to isolate the pressure pod and its color-coded sample port.
      iv. Remove pod from pressure senor housing port.
      v. Using a 3-5ml syringe filled with Normal Saline, Inject 1 ml into the sample port. (If resistance is felt, remove 0.5ml instead).
      vi. Remove needle and reinstall pressure pod in the sensor housing.
      vii. Remove clamps from the line
      viii. Resume treatment
      ix. With machine in Run mode, clamp the access line below the access pressure pod to ensure machine will alarm "Access Pressure Extremely Negative".
3. **CAUTION ALARMS:** (Yellow Light), Blood pump continues to circulate the pump related to the alarm is stopped.
   a. Incorrect weight change detected…
      i. Inspect and remedy possible causes
         1. Assess all clamps, lines, connections, ports are patent.
         2. Assess for kinking or disconnections
         3. Ensure all fluid bags are free hanging
      ii. Press Continue
   b. Scale open
      i. Inspect and remedy possible causes
      ii. Press scale toward machine until it locks closed
      iii. Press Continue
   c. "…Bag empty
      i. Change bag as directed
4. **ADVISORY ALARMS:** (Yellow Light)
   a. Filter is clotting/TMP too High
      i. Decrease the replacement and/or patient fluid removal
      ii. Increase the blood flow rate.
      iii. Assess for kinked lines in the flow path
      iv. Assess for air leak or pressure monitoring failure

ENDING TREATMENT

1. It is ideal to return the blood whenever possible. Otherwise you have an estimated blood loss of ~100ml (per Gambro).
2. **Never Return Blood** with:
    a. Suspected Anaphylactic Reaction
    b. Blood Leak Detected
    c. Clotted Filter or visible clots in the blood lines
3. Will need spike connector and Normal Saline (NS) bag
4. Press “Stop” then press “End Treatment”, then press “Return Blood”
    a. Press Disconnect if stopping treatment without returning blood.
5. Clamp the access line and access port of the catheter.
6. Disconnect blood line from port and attach a 10 ml saline syringe.
7. Unclamp and flush.
8. Attach access blood line to the spiked NS bag.
9. Press and hold “Start Return” on the screen till return line turns pink in color.
10. When completed, clamp return line and return access port and disconnect return line.
11. Flush catheter and lock both ports with locking medications (e.g.: heparin, TpA)

IF ICU RN returns the blood, be sure to have nurse NOT TURN OFF THE MACHINE—have that person leave the machine in the UNLOAD screen—till dialysis RN arrives to complete disconnect process.

Manual Termination of Treatment

1. Turn the power off. Clamp the access line (red-striped) and disconnect from the patient. Attach the access line to the NS bag (spiked connector required). Unclamp access line.
2. Press the return clamp button (located to the left side of the return line clamp assembly) in the “In” position and remove the return line (blue-striped) from the return line clamp.
3. Remove the pump crank from its holder on the rear of the Flex. Insert crank into the rotor of the blood pump and turn clockwise until sufficient blood is returned.
4. Follow standard practice for disconnecting return line from catheter.

Emergency Procedures

Prismaflex

Emergency Disconnection:

Usage: Cardiac Arrest, Hospital Evacuation, etc.

1. **Power down the Prismaflex, ON/OFF button is located on the right side of machine.**
2. **Stop all CRRT related IVs i.e. Citrate and/or Calcium.**
3. **Clamp access (red) and return (blue) lines.**
4. **Clamp both ports on the dialysis catheter.**
5. **Flush each port of the dialysis catheter with 10 ml NS and lock with 1000 unit/ml heparin (unless contraindicated) in the amount of the catheter fill volume etched on lumen.**

Replacement and/or Dialysate Unavailable:

Usage: Replacement and Dialysate temporarily unavailable from pharmacy

1. **Hang 1 liter NS in place of depleted fluid.**
2. **Reduce the flow rate of this fluid to 500 ml/hr while NS is infusing.**
3. **Order fluids "stat" from pharmacy. Notify nephrologist of event.**
4. **Change to proper solution immediately upon availability and reset flow rate to ordered amount. Avoid prolonged infusion of substitute fluids.**

NORTHWEST Kidney Centers

Manual Termination of Treatment with Blood Return

Usage: Machine malfunction, power failure, other emergency

1. Turn off power (on right towards back of machine). Spike a 1 liter Normal Saline bag and hang it on the left side of machine. Clamp access (red) line and corresponding catheter lumen. Disconnect access line from clamped catheter and connect to spiked NS bag. Unclamp access line.

2. Remove the return (blue) line from the return line clamp.

3. Visually check for air in the return (blue) line until patient is disconnected. DO NOT return blood to patient if air is present in the return line.

4. Remove the pump crank from the back of machine. Insert crank into the slot on blood pump and turn clockwise until blood is returned to patient.

5. Clamp the return (blue) line and corresponding catheter lumen. Disconnect the return line from the patient.

6. Flush each port of the dialysis catheter with 10 ml NS and lock with 1000 unit/ml heparin (unless contraindicated) in the amount of the catheter fill volume etched on lumen.

The ICU/CCU nursing care of a patient includes but is not limited to:

1. Temperature

   Body temperature should be monitored every two hours, at least. This is because a significant amount of heat is lost as the blood makes its way through the extra-corporeal circuit. CRRT patients will drop their temperature by at least 2$_{o}$C despite the fact dialysate fluid is run through a warmer prior to entering the filter. Heating lights or warmed blankets are an option, but care must be taken not to cover the lines as this increases the risk of disconnection. If a patient receiving CRRT is pyrexial, then it is likely they have a systemic infection, so WBC and Blood Cultures should be checked. The results of these checks will indicate the presence and type of infection, if there is one. The patient's blood, via the filter fibers, is being bathed in cool dialysate fluid, and heat will be lost through the filter itself- therefore we heat the dialysate fluid to reduce the amount of heat lost.

2. Cardiovascular

   Continual cardiac monitoring is necessary because CRRT effects cardiovascular function, as a rapid change in serum electrolytes, such as potassium or magnesium, can cause arrhythmias. Regular sampling of blood is required to monitor electrolyte and acid-base imbalances, so treatment can be adjusted accordingly and supplements administered if necessary. Accurate recording of fluid levels is important, to ensure that the patient does not become hyper - or hypo-volemic; the patient relies on external forces to control their internal environment. A common problem when on CVVHDF is hypotension. To maintain adequate blood pressure, inotropes may be used. The use of a pulmonary artery catheter and cardiac index gives an indication of the need for fluids or inotropes. The fluid balance in a patient receiving CRRT can be adjusted in two ways. The first is by removing more or less fluid via CRRT; the second is by administering more or less fluid intravenously. This ensures there is an adequate central venous pressure to maintain dialysis.

3. Respiratory

   Dialysis can cause changes in a patient's fluid balance; therefore it is important to closely monitor respiratory effort, the use of accessory muscles, signs of tachypnea, distress, fatigue and signs of infection (regular sputum samples sent for culture). Such monitoring is essential to discover or prevent the development of pulmonary edema or pleural effusions. For patients that are requiring noninvasive or invasive ventilation there may be the need for an increase in Positive End Expiratory Pressure (PEEP) or Pressure Support (PS) requirements, as the recent acidosis or metabolic derangement may have caused the patient to overuse respiratory muscles. These can be rested with the use of PEEP and PS.

4. General observations

   In order to maintain the system's patency, hourly checks of the catheter site (looking for redness, oozing/bleeding and pain), dialysis lines and filter pressures, should be carried out. These checks give early warning of unwanted side effects such as accidental disconnection, air in a line or premature clotting of the filter, as well as signs of infection.

5. Position

The catheter access sites commonly used at Hornsby Hospital in ICU are via the subclavian or internal jugular veins. This may create a problem with positioning the patient as the line needs to remain patent at all times. Positioning the patient on the catheter side will often occlude the catheter as the increased pressure causes the catheter to be advanced slightly. Patients still need to be turned at least every 2hours to maintain good skin integrity. They are often at a higher risk of pressure ulcers due to their compromised state.

6. Anticoagulation

Most CRRT patients will require some form of anti-coagulation, which should be closely monitored to ensure that optimal anticoagulation is achieved. This will be assessed according to the type of anticoagulation given.

7. Neurological

Reduced levels of consciousness, increased restlessness, agitation and aggression are indications of neurological status changes. These changes result from raised creatinine levels, slow excretion of sedatives and levels of pain. Treatment of pain needs to be very carefully titrated to ensure that the patient is pain-free but not over-sedated. There may be the need for Patient Controlled Analgesia (PCA) to control their pain. A large number of patients that require CRRT will also be septic and hence require ventilation. This may require the patient to be sedated to maintain comfort and compliance with ventilation. This often affects the blood pressure which in turn affects renal blood flow, possibly worsening renal failure.

8. Nutrition

Another nursing care consideration is the nutrition of the patient, especially if they are to be dialyzed for a prolonged period of time. Due to the increased metabolic rate of ill patients, many are not able to absorb provided nutrients and this can lead to gut atrophy. The use of enteral feeding is beneficial, as the feed helps to line the gut, protecting it from gastric acids. If the patient is able to eat normally then a dietician should be involved to ensure that a correct balance of nutritious foods is supplied. If the patient is unable to tolerate enteral feeding, Total Parenteral Nutrition (TPN) may be considered.

9. Psychosocial

A dialyzed patient will be concerned, and possibly anxious, about the machine, of the blood coming out of their body and the long-term implications of ARF. The presence of uncontrolled pain will add to these fears, as will the lack of control over what is happening to their body. Regular education of the patient and family is of utmost importance. To achieve this, simple explanations of ARF and dialysis are required. The inclusion of a social worker can be beneficial, as are regular visits by family. An Occupational Therapist can assist in offering diversional therapy activities.

10. Indwelling Catheter

The development of a urinary tract infection is a side effect of anuria, as the lack of urine output allows microbes to travel up the catheter. The removal of the urinary catheter is advisable until the patient recommences micturating.

NORTHWEST Kidney Centers

Continuous Renal Replacement Therapy Self-Test

1. List five reasons for instituting Continuous Renal Replacement Therapy (CRRT)?
    a. ____

2. Briefly describe the principle of diffusion.
    a. ____

3. Briefly describe the principle of Ultrafiltration.
    a. ____

4. Explain what is meant by the term convection?
    a. ____

5. Explain the term "counter current" flow, why is it beneficial?
    a. ____

6. Even though the dialysate is heated patients often become hypothermic. Why is this so and what nursing interventions can you utilize to prevent hypothermia?
    a. ____

7. Why does the patient on CRRT require anticoagulation?
    a. ____

8. What is the purpose of the air detection system and clamp found on the return line of the PrismaFlex machine?
    a. ____

9. How do we regulate serum K+ levels when a patient is on CRRT?
    a. ____

10. What regular blood tests are required by a patient on CRRT and why?
    a. ____

11. List the potential complications of CRRT?
    a. ____

12. What does the APTT test check?
    a. ____

13. The PrismaFlex machine has five pumps. Name them and describe their function.
    a. ____

14. Why are the dialysate, replacement and effluent bags hung on scales?
    a. ____

15. What is the purpose of “pre-dilution”?
    a. ____

16. If the “access pressure” becomes extremely negative and alarms - what are the potential causes and how can you trouble shoot?
    a. ____

17. What is the function of the blood leak detector?
    a. ____

18. If the blood leak detector fails to “normalize” during the priming procedure what should you check?
    a. ____

19. If the blood leak detector alarms due to a blood leak what action should be taken?
    a. ____

20. Is it possible to interrupt CRRT on the PrismaFlex to send your patient to CT?
    a. ____

21. Briefly describe the procedure to return blood to the patient prior to ending treatment?
    a. ____

22. What is indicated by high transmembrane pressures? What action can you take in an effort to lower them?
    a. ____
    ____

23. Is it possible to change the bags during a treatment, if so describe the process?
    a. ____
    ____

24. If the periodic "self-test" fails- what action should be taken?
    a. ____
    ____