Continuous Renal Replacement Therapy Learning package

NAME: _____

Prepared by:

McDermott, Wanda (Clinical Nurse Educator, Intensive Care, Hornsby Ku-Ring-Gai Hospital)
Melloh, Jo (Clinical Nurse Specialist, Intensive Care, Hornsby Ku-Ring-Gai Hospital)
Smyth, Anneke (Clinical Nurse Specialist, Intensive Care, Hornsby Ku-Ring-Gai Hospital)

Reviewed by:

McDermott, Wanda (Clinical Nurse Educator, Intensive Care, Hornsby Ku-Ring-Gai Health Service)
Melloh, Jo (Acting Clinical Nurse Educator, Intensive Care, Hornsby Ku-Ring-Gai Health Service)
Ford, Paula (Acting Clinical Nurse Educator, Intensive Care, Hornsby Ku-Ring-Gai Health Service)
Smith, Kyla (Nursing Unit Manager, Intensive Care, Hornsby Ku-Ring-Gai Health Service)
Halkhoree, Jay (Clinical Nurse Consultant, Intensive Care, Hornsby Ku-Ring-Gai Health Service)

Endorsed by:

Halkhoree, Jay (Clinical Nurse Consultant, Intensive Care, Hornsby Ku-Ring-Gai Health Service)
Stern, Adrienne (Staff Development Educator, Hornsby Ku-Ring-Gai Health Service)

Prepared: February 2008
Reviewed/updated: April 2010
Review due: April 2013

PAGE TABLE OF CONTENTS

4	Introductory information
5	Continuous Renal Replacement Therapy (CRRT) history and definition
6	Terms
11	Mechanisms of dialysis therapy
17	General guidelines for use
19	Differences between Prisma and Prismaflex dialysis machines
21	Peritoneal Dialysis
22	Intermittent Haemodialysis
23	Slow Continuous Ultrafiltration
25	Continuous VenoVenous Haemofiltration
27	Continuous VenoVenous HaemoDialysis
29	Continuous VenoVenous HaemoDiaFiltration
31	Short Term High Volume HaemoFiltration
31	Pre or Post Dilution
32	Therapeutic Plasma Exchange (TPE)
32	Charcoal Haemoperfusion
33	General Nursing Guidelines for patients receiving CRRT
35	Troubleshooting
35	Manipulating the Principles of Dialysis
36	Alternative Anticoagulation Therapies
37	References
38	Worksheet
43	CRRT Competency
46	Candidate's descriptor and matrix of the CRRT Competency

Introductory Information

Purpose of the Package

The purpose of this package is to provide comprehensive information to promote an understanding of the principles of dialysis that may assist the nurse to care for patients receiving Continuous Renal Replacement Therapy (CRRT).

Expectation of Prior Learning

There is an expectation that the staff member completing this learning package will have an existing understanding of the Anatomy and Physiology of the renal system, and is able to perform a renal assessment prior to completing this learning package.

Target Audience

It is expected that all staff caring for patients on dialysis will complete this learning package.
This package will be useful for both the novice as well as those who would like to revise their knowledge on the subject.

Aims and Objectives

By completing this learning package, staff will be able to:

- explain the conditions under which dialysis may be required.
- acquire the knowledge and skills necessary to competently care for a patient receiving dialysis.
- explain and prevent possible complications to the patient while on dialysis.
- take an active role in their own professional development.

Mode of Delivery

This is a self-directed learning package. Regular CRRT workshops and in-services will be presented to ICU staff to provide additional information.

Assessment Process

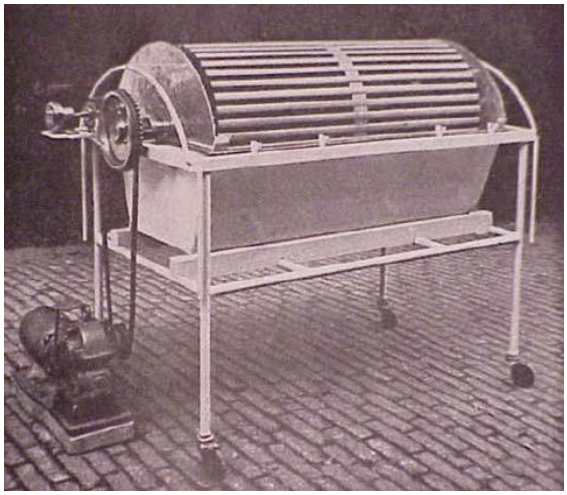
Following completion of the learning package and worksheet, the RN is required to successfully complete the CRRT competency. The competency must be assessed by an accredited assessor who has previously completed the competency.

Directions for use

1. Study the learning package.
2. Complete the worksheet.
3. Clinical Nurse Educator/Facilitator on the Unit/Ward will mark completed worksheet.
4. Assessment of competence using the “CRRT competency”.
5. Documentation of competence recorded in staff member’s education records.

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 on 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 "Dialysis" or HD (haemodialysis), it performs the functions of the human kidney externally to the body.

HD can be both VenoVenous (VV) access or ArterioVenous (AV) access. The most common is VV access, but all types of HD can be done by AV as well.

There are many different types –

- PD – peritoneal Dialysis
- IHD – Intermittent HaemoDialysis
- SCUF – Slow Continuous UltraFiltration
- CVVH – Continuous VenoVenous HaemoFiltration
- CVVHD – Continuous VenoVenous HaemoDialysis
- CVVHDF – Continuous VenoVenous HaemoDiaFiltration
- STHVH – Short Term High Volume HaemoFiltration

When do we dialyse?

- 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?

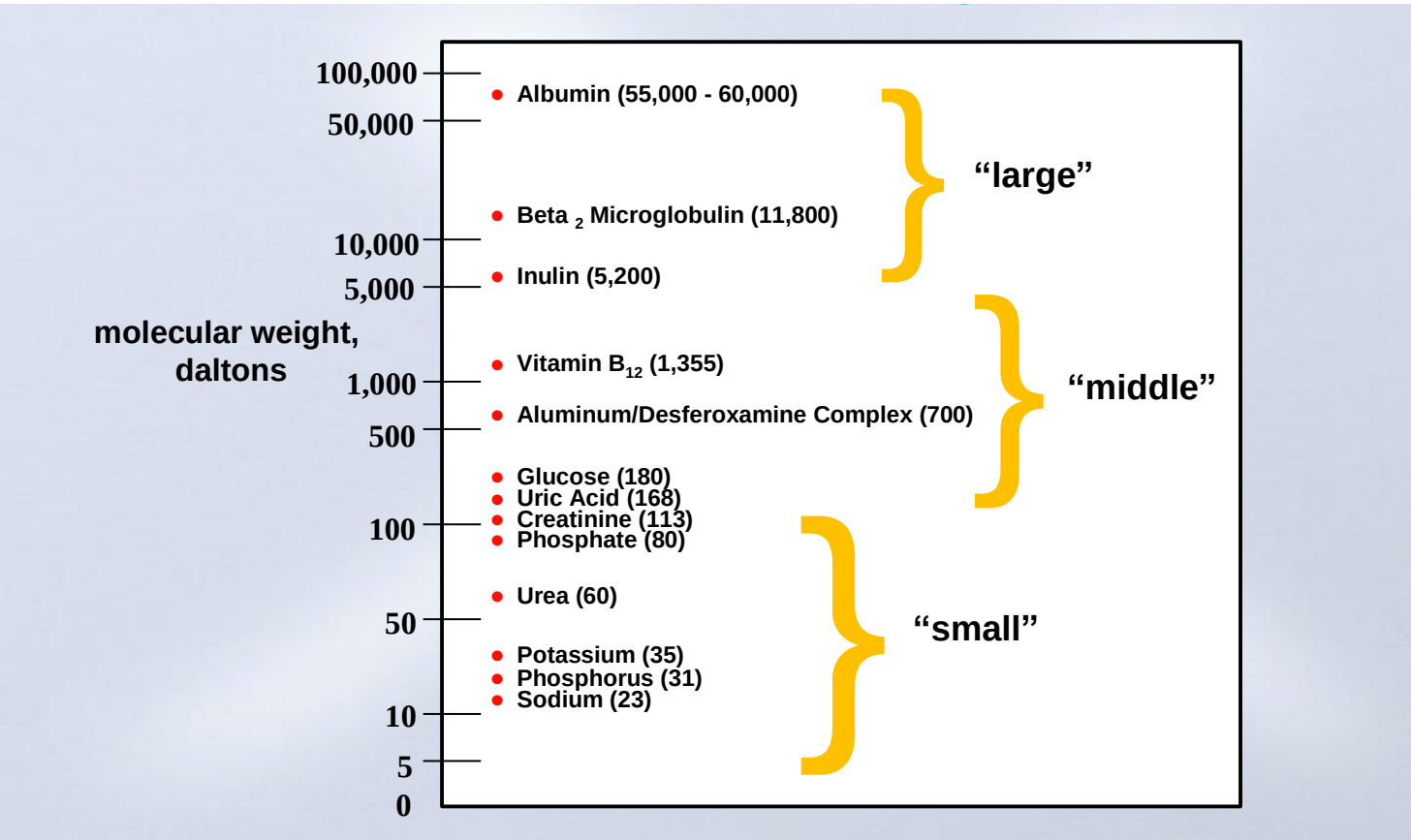
- Process by which solutes move passively down their concentration gradients, from one fluid compartment into the other (either blood or dialysate).
- Urea, Creatinine and Potassium move from the blood to the dialysate fluid.
- Calcium, Bicarbonate and other solutes move from the dialysate to the blood.
- The dialysate creates a "countercurrent" to the blood flow, maximising the concentration gradient between the compartments, which in turn maximises 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 (eg glucose) can be dissolved in a liquid (eg 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.

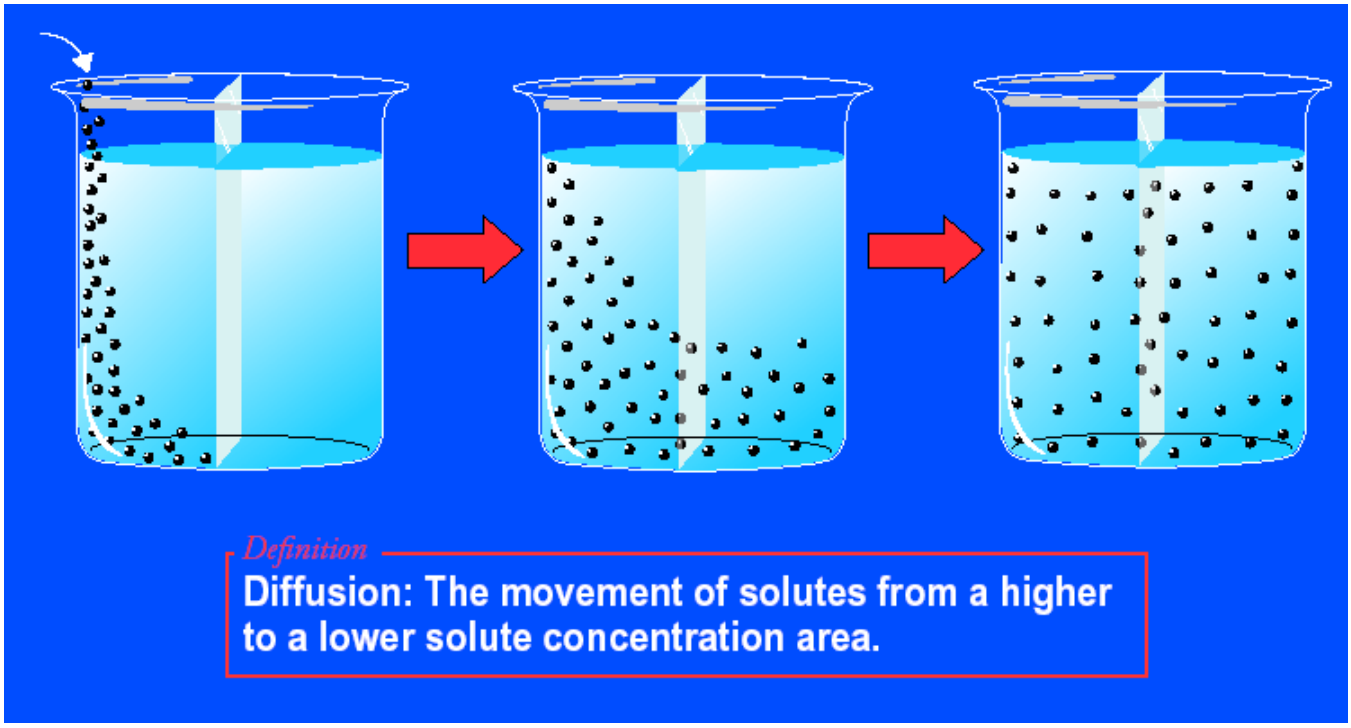


Osmosis is –

- 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 equalise.

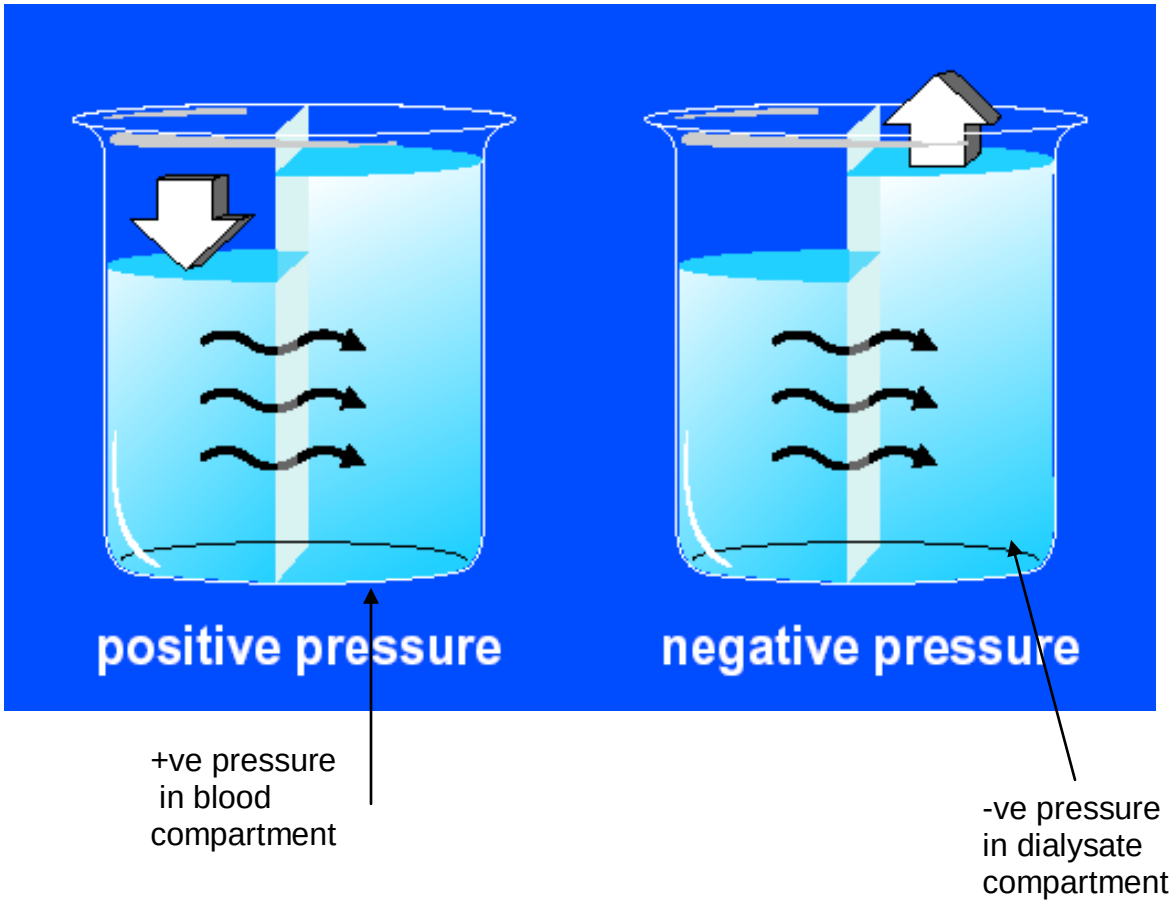
Diffusion is –

- 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 dependant on;
  - surface area of filter
  - ratio of dialysate flow to blood flow
  - size of the molecules



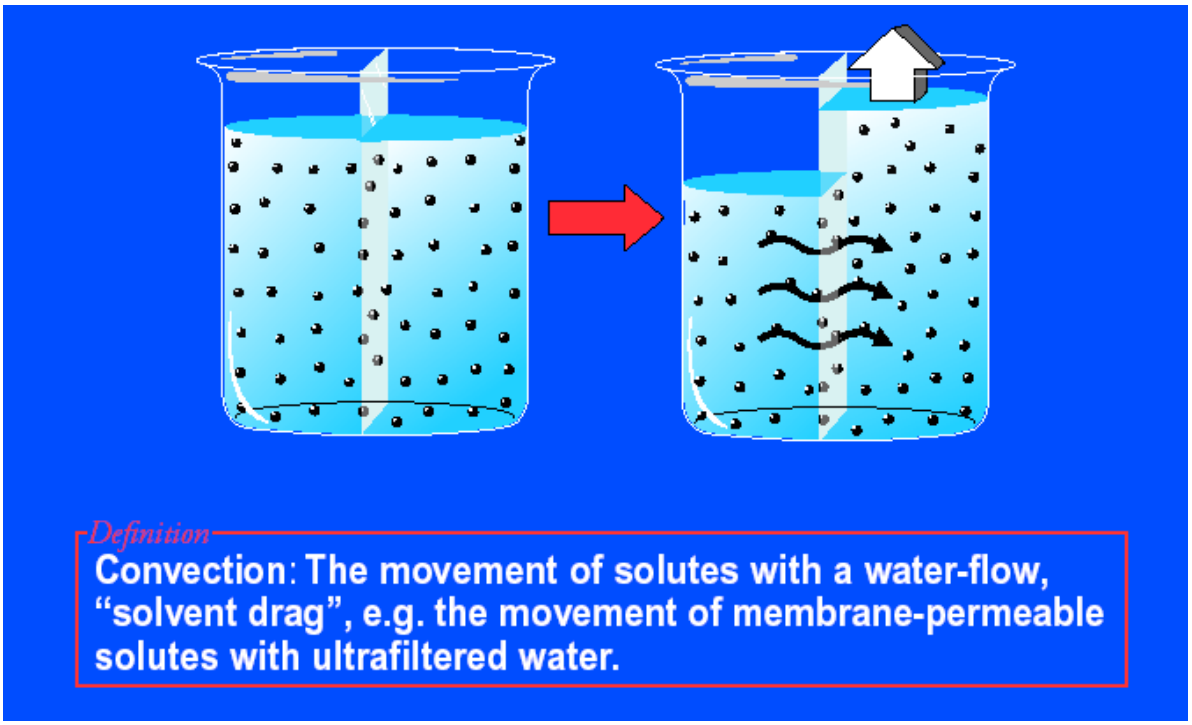
Ultrafiltration is –

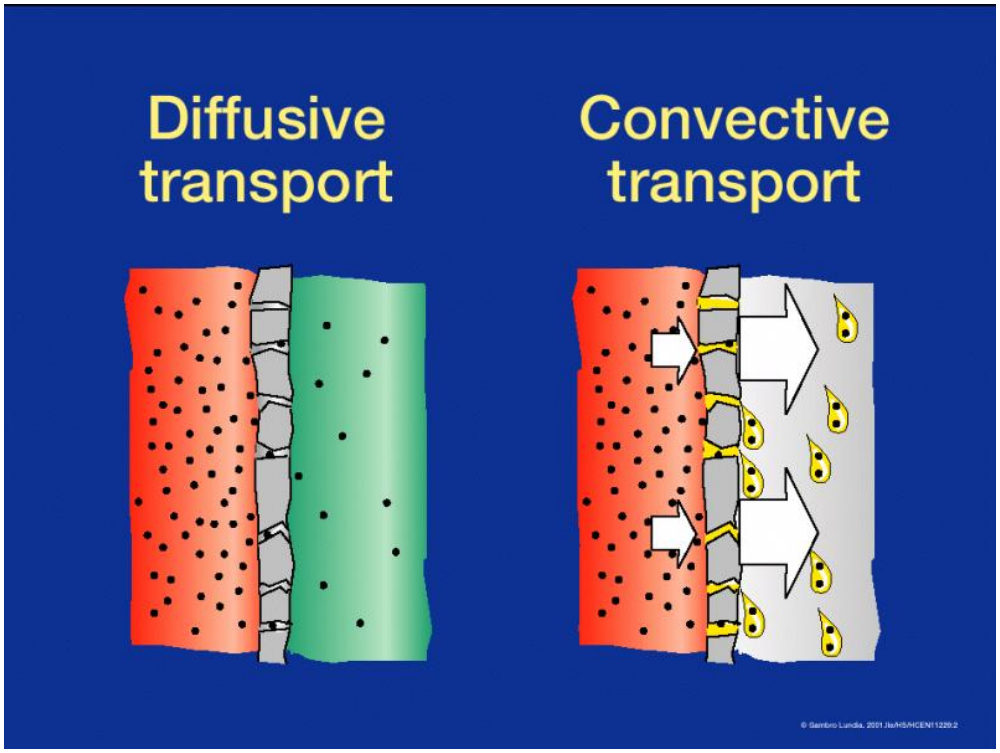
- the movement of fluid through a membrane caused by a pressure gradient (hydrostatic or osmotic pressure).



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



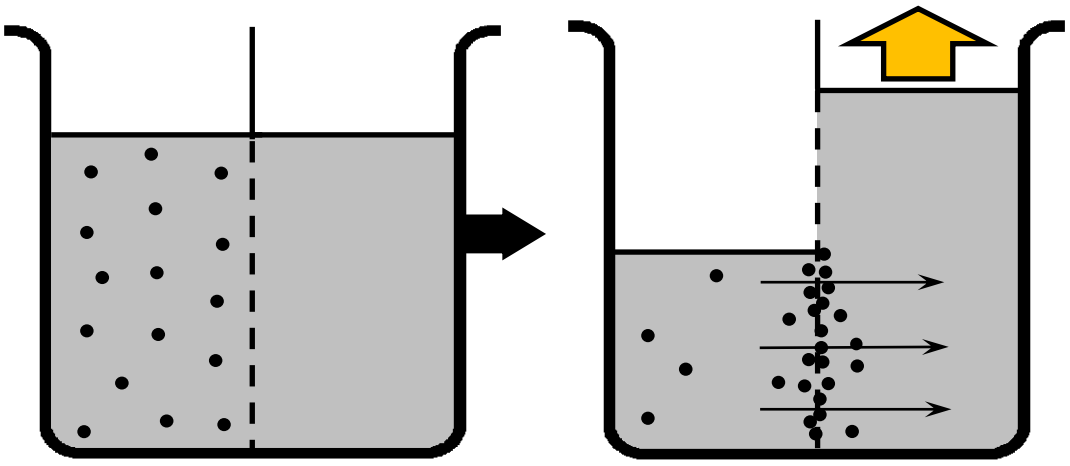


Adsorption occurs –

- 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 can not 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

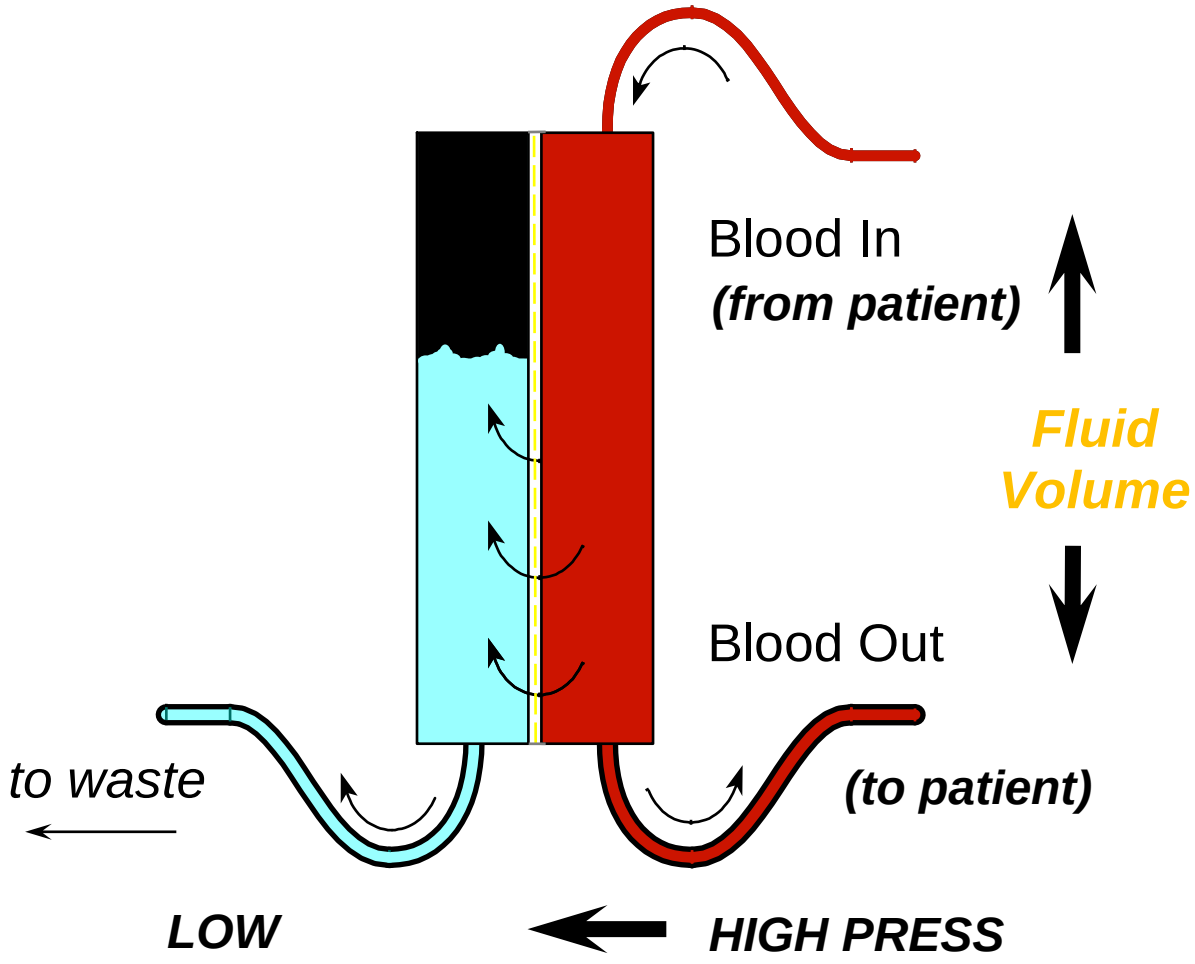


Mechanism of Dialysis

Dialysis therapy uses the mechanisms of ultrafiltration, haemofiltration and haemodialysis. The different modes utilise a selection of one or more of these mechanisms.

Ultrafiltration

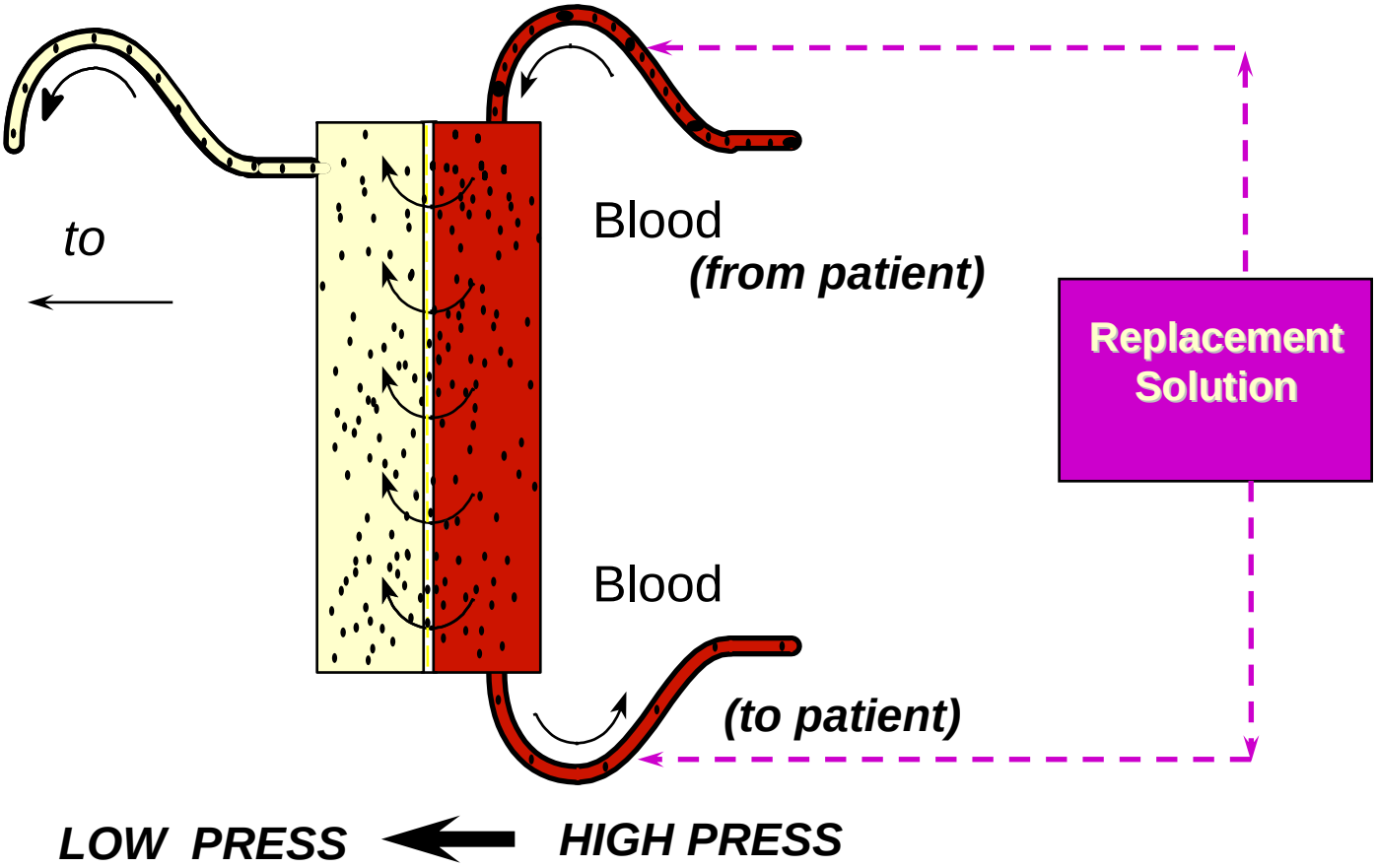
Plasma water with solutes is drawn from the patient's blood across the semipermeable membrane in the filter. The effluent pump controls the ultrafiltration rate automatically according to the set flow rates.



Haemofiltration

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.

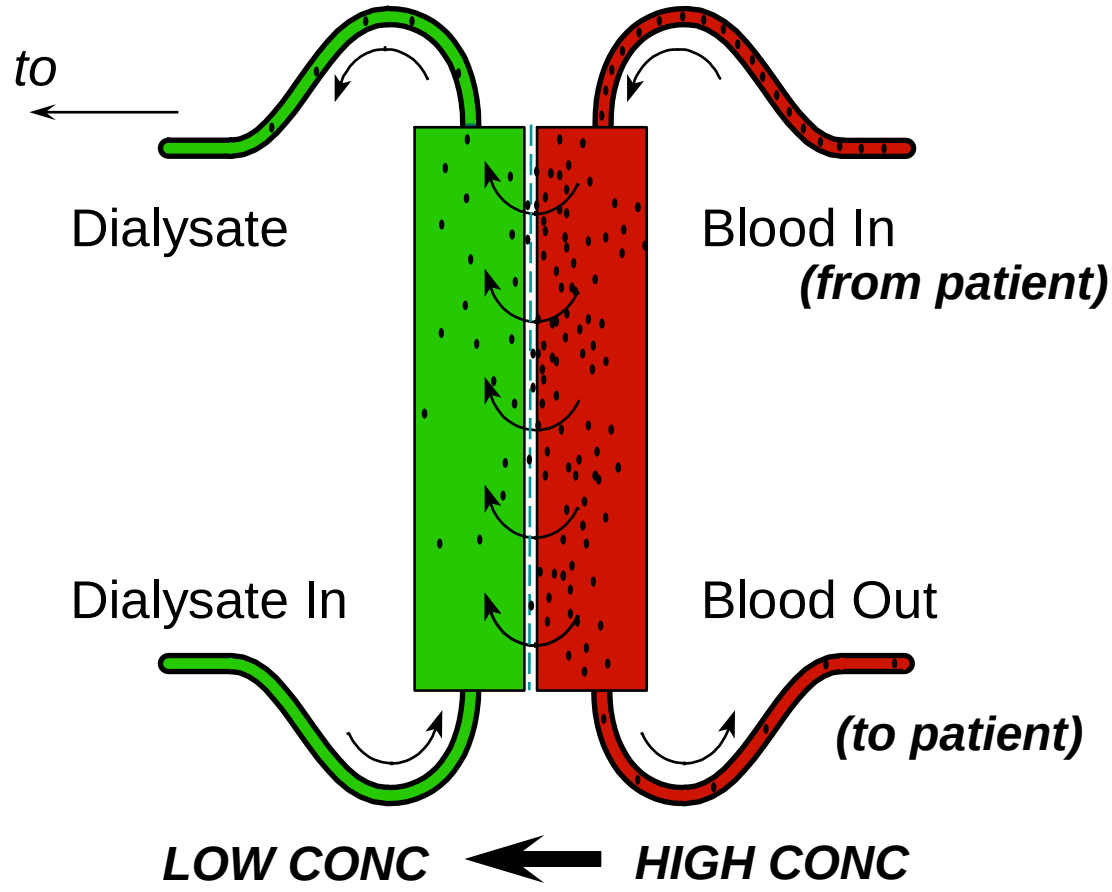
The replacement solution replaces some or all of the water removed, as well as the desired solutes. Unwanted solutes are not replaced, thus their concentration decreases in the patient's blood. Solute removal is achieved by convection (solvent drag across the membrane).



Haemodialysis

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.

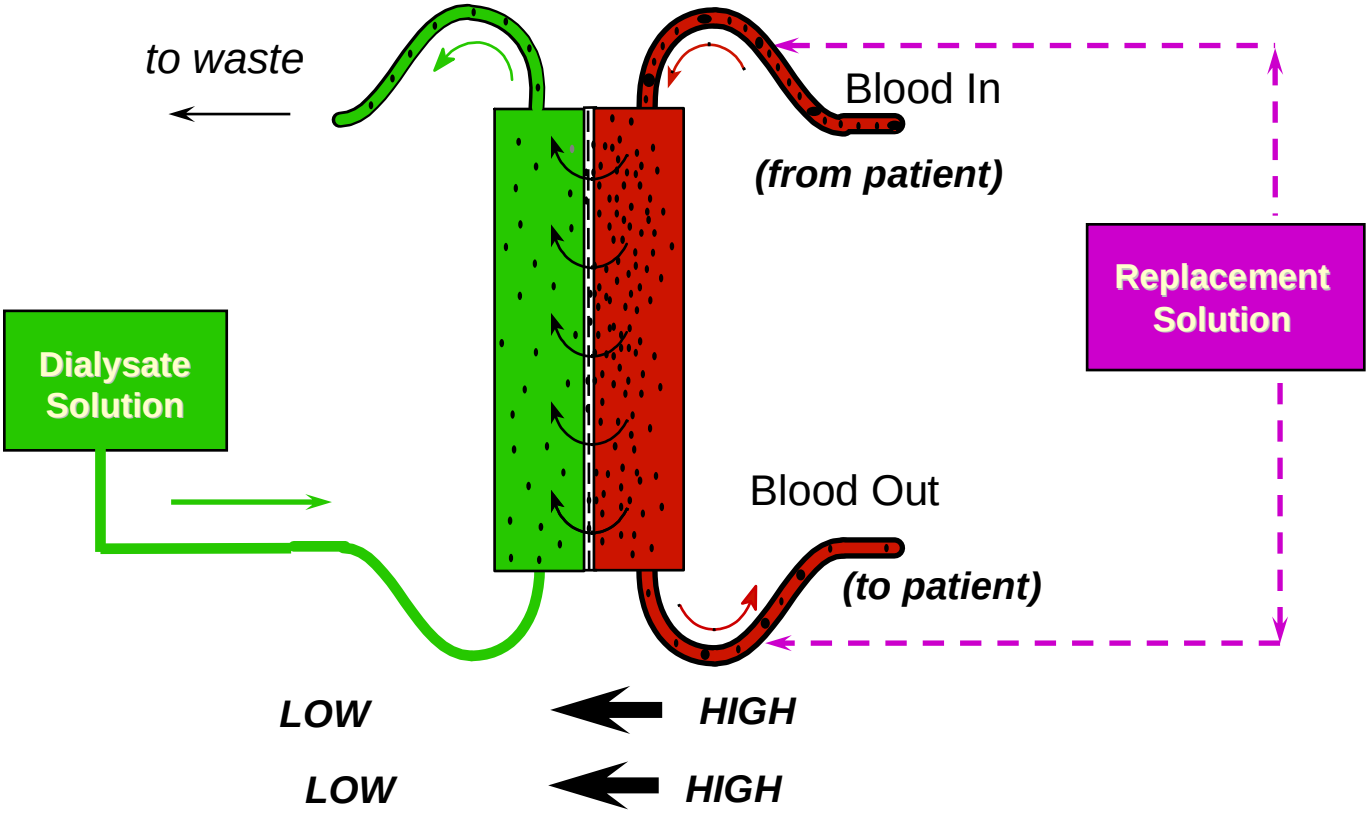


HaemoDiaFiltration

In HaemoDiaFiltration, both haemodialysis and haemofiltration 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.

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.

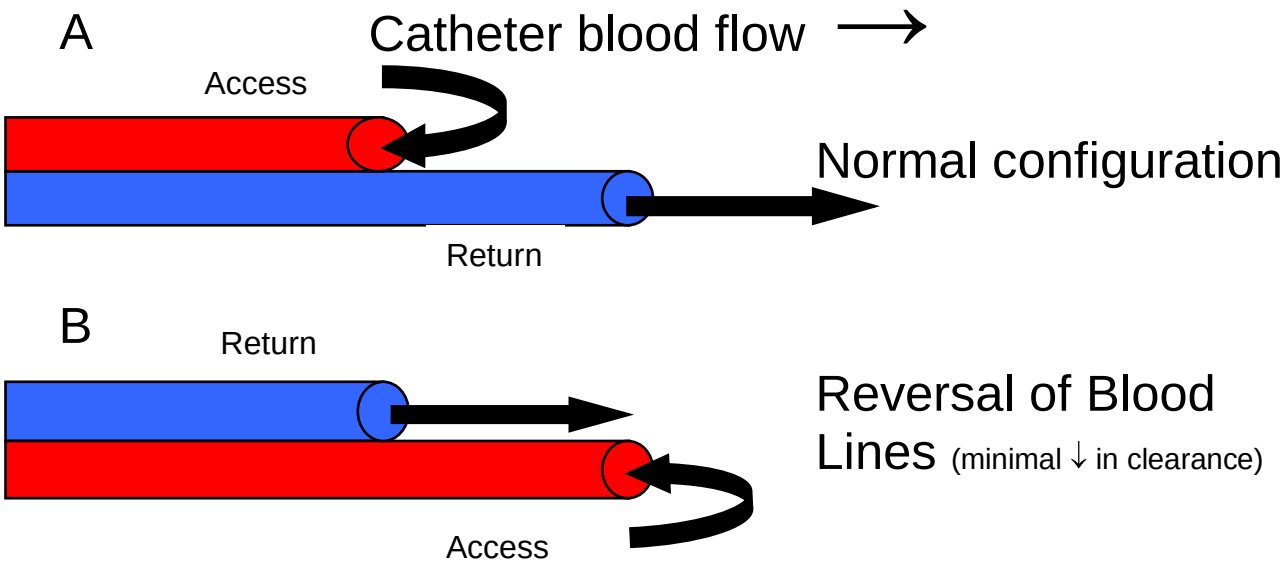


What do you need?

- 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 fluid (see page 36)
    - 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 predilutional fluid that connects into the access line close to the patient. This allows for both a predilution fluid as well as a post dilution replacement fluid.

The Vascath

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.

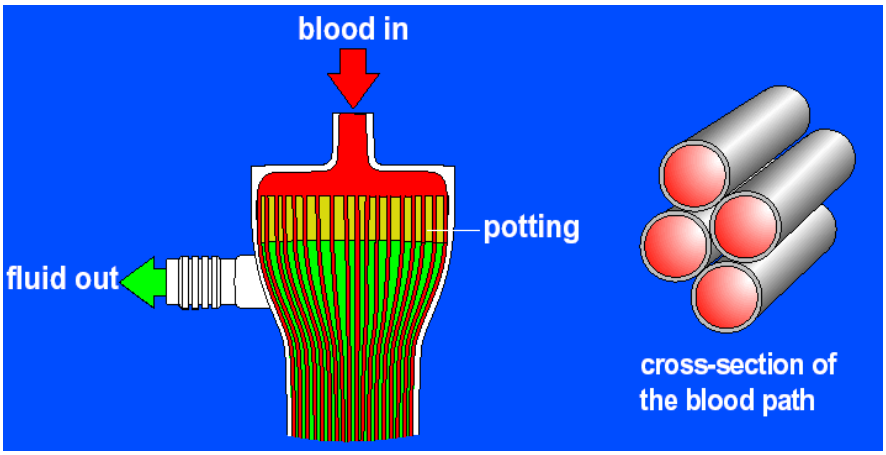


The fluids

- The composition of the replacement, dialysate and predilutional fluid is a standard solution with a predetermined concentration of base (usually bicarbonate) and ions.
- We can customise the solution by adding potassium.
- There are fluid bags that contain lactate as a base or which contain low or no lactate in the fluid.
- Low lactate bags are the default bags we use at Hornsby Hospital in ICU (Hemosol BO).

The Filter

- Is made of many thousands of small hollow fibres (8000-9000).
- Each fibre is manufactured with small pores, through which water and its contained solutes pass.
- The fibres are bundled together in a tube.
- They are enclosed in the tube. The ends of the fibres remain open, enabling blood to enter at one end and exit at the other but not circulate outside the filter.



The Machines

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

At Hornsby Hospital ICU we have 2 Prisma machines and 1 Prismaflex machine. The Prisma and Prismaflex Continuous Fluid Management (CFM) 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.

PRISMA

PRISMAFLEX

General Guidelines

- Prior to the commencement of CRRT it is important to check that there is adequate stock of all necessary items such as:
    - Vascaths
    - Dialysis circuits
    - Fluid bags (containing lactate or low lactate solutions)
    - Tubing for blood warmer
    - Potassium
    - Heparin
- A clean, “no touch” technique is used while priming and preparing the filter and lines.
- An aseptic technique is used to connect lines to the vascath or when accessing the vascath for any reason including dressings.
- Prisma (ST100) & Prismaflex (ST150) sets come in both pre and post dilution set ups. The difference being whether the replacement fluid runs in before or after the filter. We use the predilution sets unless otherwise ordered.
- Standardised orders have been developed for the Heparin Infusion and the flow rate. Although we use a syringe to administer the Heparin infusion, we do NOT recommend using the syringe facility on the machine (as it is not accurate in its delivery of the infusion due to the low infusion rates required). We use a separate syringe driver that must be at the same level or higher than the filter or back flow into the line will occur.
- 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 Intensivist/Registrar. This amount is above the removal of the replacement fluid + dialysate fluid and PBP fluid that is going though 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.
- 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. Both bags should be labelled with the patient’s addressograph sticker. The bag not in use should be capped off when it has drained to keep it clean. This is achieved by placing the luer lock end of tubing in a small alcowipe swab and holding it in place with yellow forceps. This is then changed each time the bag is changed. (NB: The effluent is sterile and is draining away from the patient so this practice does not put the patient at risk.) An effluent bag trolley is utilised both during the change and to drain the bag into the sluice. Its purpose is to reduce the risk of back injury and contamination of the bags while they drain.

General Guidelines Contd.

- 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 eg: 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 vascath 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. This is dependent on the patient's condition and the expertise of the nurse running the patient onto dialysis. In some situations it is recommended that the patient does not receive the priming solution eg. Heparin Induced Thrombosis-Thrombocytopaenia Syndrome (HITTS).

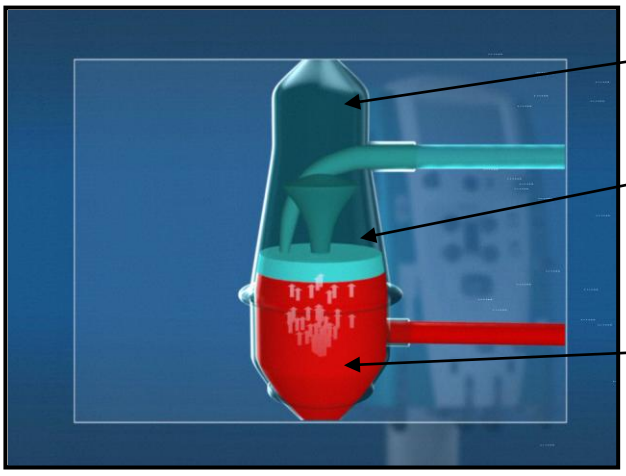
Differences between the Prisma and Prismaflex machines

The Prisma and Prismaflex machines both utilise the same modes:

- SCUF
- CVVH
- CVVHD
- CVVHDF
- TPE
- Charcoal haemoperfusion

The Prismaflex features:

1. There are priming hooks on the sides of the machine to decrease any OH&S injuries with lifting the 5 litre 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 patients electrocardiogram (ECG) recordings.
5. 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.
6. 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*.
7. 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.
8. The effluent pressure pod is not always primed during priming but once the machine does the pressure pod PRIME TEST it fills this up.
9. The Astrotherm II blood infusion warming tubing is also different as it is thicker and fits into the new warmer that has an adjustable temperature setting.
10. 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.



The top end of the deaeration chamber is connected to the return pressure line

The post replacement solution sits on top of the blood , reducing the blood-air interface and hence potential for clotting.

The blood enters at the bottom of the chamber. This level needs to be checked hourly to reduce the risk of clots and air entering the blood returning to the patient.

The Prismaflex has additional lines to the Prisma:

1. Pre Blood Pump, PBP (White Line). This line is the equivalent of running pre replacement solution. It joins the access line close to the patient which allows it to dilute the blood for a longer period of time. It also allows the blood and PBP to run at higher flow rates which improves clearance rates and assists in prolonging the life of the filter. This is set at a flow rate of 1500- 2000ml/hour.

2. The Dialysate Line (Green Line) This line still creates the counter current inside the filter. Iit is also the line that should be warmed to reduce the amount of heat loss to the patient. The usual solutions that are used are a bicarbonate based solution which, when warmed, will create air bubbles. This is not a problem when it is on the dialysate line as there is no direct contact between the blood and dialysate solution. The normal flow rate for this is set at 500ml/hour on the Prisma and 1000ml/hour on the Prismaflex.

3. The Replacement Line (Purple line) on the Prisma is always a Pre dilution fluid that joins the access line just before the filter and is set at flow rates of 1500ml/hour, up to a maximum of 2000ml/hour. On the Prismaflex the replacement line can be either pre or post dilution. We tend to use it as a *post* dilution fluid as we run the PBP as a pre dilution fluid. On the Prismaflex this post filter line joins the return line at the deaeration chamber, this is done for 2 reasons:

   a. Allows for a decrease in blood air interface and therefore decreases the risk of clotting.
   b. It allows us the option of running an alternative post filter fluid such as Calcium if using Citrate as an anti-coagulant.

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

• The Prismaflex is capable of running at much higher rates with all fluids and so allows for more effective CRRT treatment.
• 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 colours on the two machines remain the same,
   Green light if all is running correctly,
   Orange if it is a non-urgent alarm (bag change due- the blood pump heads will continue to turn during this alarm)
   Red if there is serious problem.(the blood pump heads will stop if this alarm is activated).

6. Recirculation / 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 / re-circulate or change the set. On the Prisma you are only given 2 options (end treatment or change set). To re-circulate the filter it is necessary to follow the unit written policy.

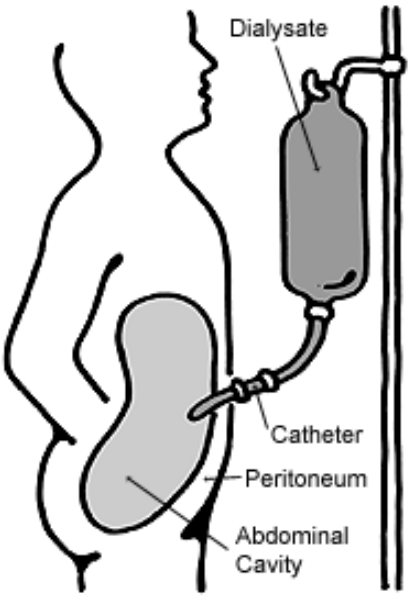
7. Retuning the blood. The patient’s blood should be returned whenever possible. This is a clinically based decision, but generally if the machine gives you the option of returning the blood then you can. If there are visible clots in the circuit then it might be safer not to, but you can always start returning the blood and stop immediately any clots are seen.

Peritoneal Dialysis

- A catheter is inserted in the peritoneal cavity.
- A glucose-rich fluid is drained in over a set period of time.
- The peritoneal lining acts as a membrane.
- The fluid remains inside the cavity for set period of time,
  allowing osmosis,
  diffusion and
  convection to occur.
- The fluid is then drained out over a set period of time into a collection bag.
- The fluid contains waste products and excess fluid.
- Twenty-minute rule.
- Water is dragged out of patient by the dextrose solution.

Advantages:

- No anticoagulation required
- No direct blood access needed
- No specialised staff required
- Inexpensive
- Maintains haemodynamic stability
- Gentle removal of fluid and solutes
- Good fluid removal



Disadvantages:

- Time consuming
- Needs intact peritoneal cavity
- Increased rate of infection
- Strict fluid balance required
- Daily weight documentation
- Can compromise respiratory status
- Requires specialized glucose enriched dialysate bags
- No control over fluid removal volume

Intermittent HaemoDialysis (IHD)

- Uses a specific machine.
- Normally done for patient awaiting kidney transplant or with severe chronic renal failure where a transplant is not possible.
- Requires the patient to have a graft site.
- It does not use an anticoagulant, replacement solution or dialysate.

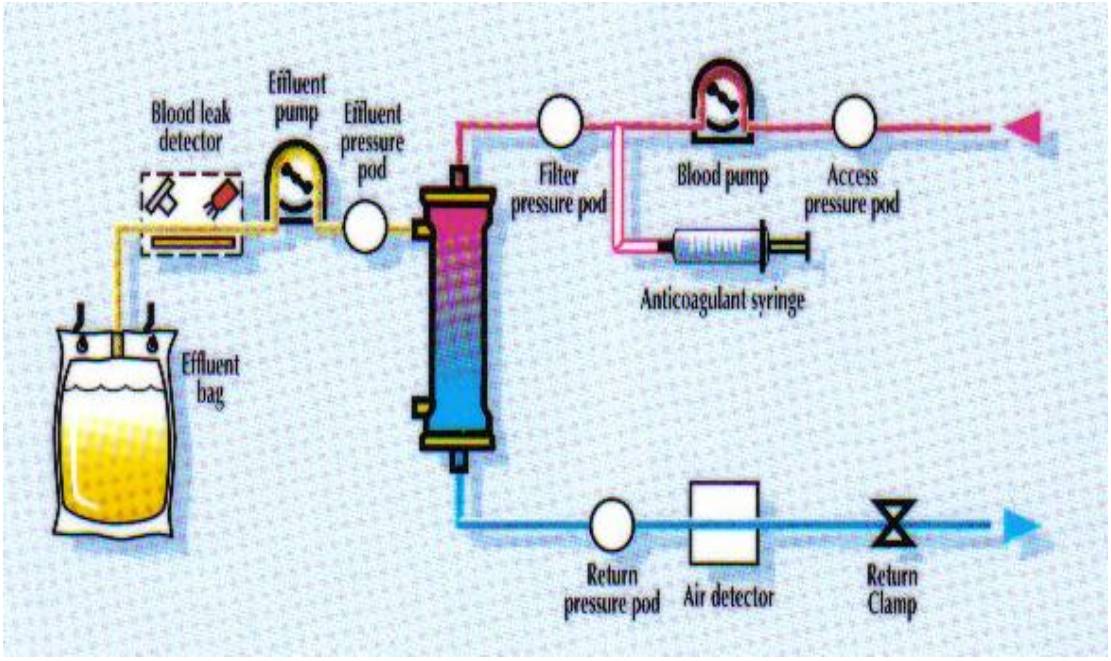
Advantages

- Rapid fluid removal
- No anticoagulation
- Large diffuse volumes
- No hospitalisation required

Disadvantages

- Graft site needed
- Continual interruption of life style
- Daily weight documentation
- Large swings in electrolyte levels between treatments
- Strict fluid balance

PRISMA Slow Continuous Ultra Filtration (SCUF)



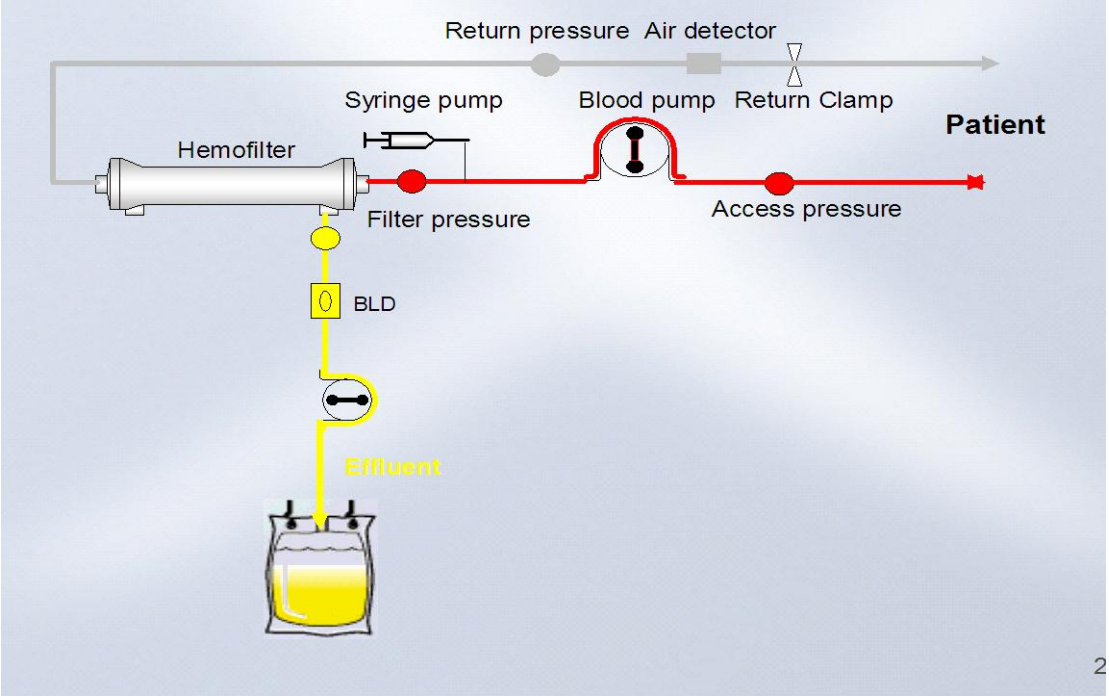
PRISMA Systems (2000). *An integrated system for continuous fluid management and renal replacement therapies: Operator's Manual.* Basel, Switzerland: HOSPAL AG.

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. To perform SCUF you require a circuit that has a specific filter, it needs to have an access, a return line and effluent line.

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.

Advantages	Disadvantages
○ Controls fluid removal volumes ○ Maintains cardiovascular stability ○ Treatment of choice in patients with heart failure	○ May require anticoagulation ○ Minimal solute clearance ○ Requires arterial and venous access ○ Requires hospitalisation ○ Increased infection rate and vessel trauma

PRISMAFLEX: Slow Continuous Ultra filtration (SCUF)



PRISMAFLEX Systems (2007). *An integrated system for continuous fluid management and renal replacement therapies: CRRT basics power point presentation, Sydney Australia.*

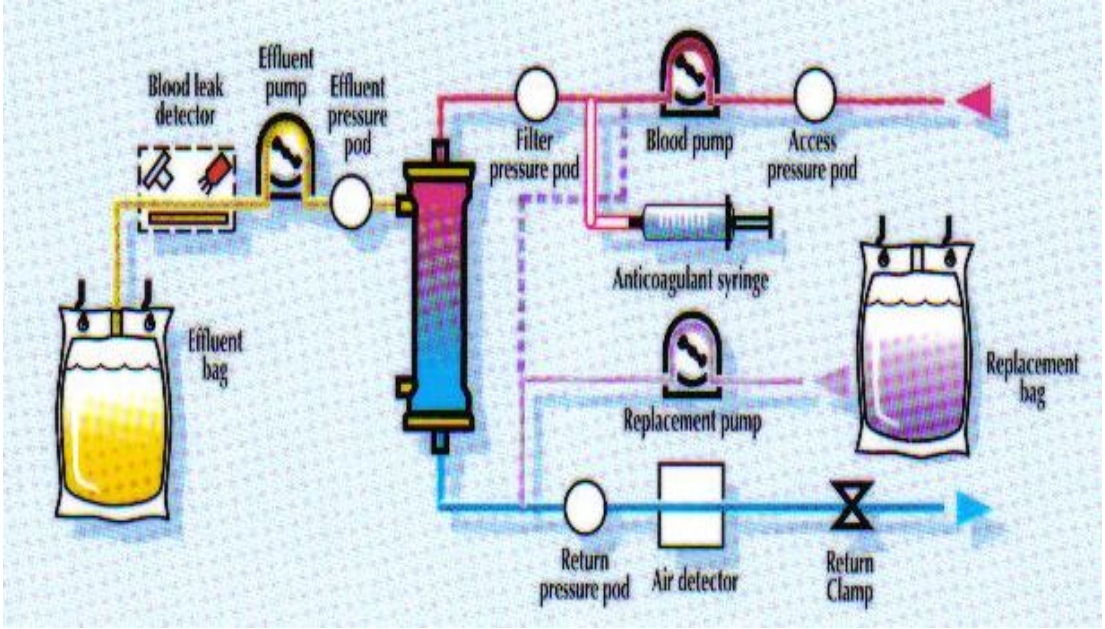
The set on the Prismaflex is the same as the Prisma, there are no additional lines / bags.

Primary therapeutic goal:
Safe management of fluid removal
No dialysate
No replacement
No PBP
Large fluid removal via ultrafiltration

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

REMEMBER: This therapy is best suited to severely hypervolemic patients (i.e. post open-heart surgery, post resuscitation, etc.) and is not generally employed for lengthy periods of time. It is not uncommon to remove fluid from the patient over a short (8-12 hour) time period and then to disconnect the treatment.

PRISMA: Continuous VenoVenous Haemofiltration (CVVH)



PRISMA Systems (2000). *An integrated system for continuous fluid management and renal replacement therapies: Operator's Manual.* Basel, Switzerland: HOSPAL AG.

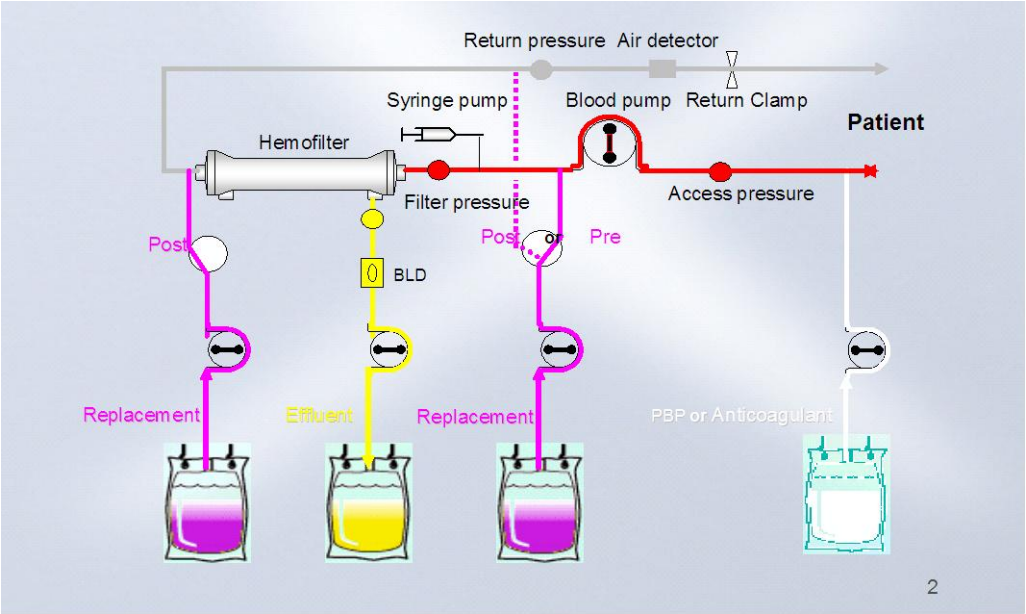
Haemofiltration uses the same process as SCUF to remove up to 1.2 litres per hour. This rate of fluid removal will obviously result in haemodynamic instability and therefore requires the replacement of large amounts of fluid.

The fluid used to replace the ultrafiltration excess is usually commercially available haemofiltration fluid. On the Prisma machine the replacement solution is run either pre or post filter, but not both.

To perform CVVH you require a circuit that has a specific filter, it needs to have an access, a return line, effluent line and a pre/post replacement line.
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.

Uses:
Convection
Ultrafiltration
Adsorption.
Treatment of patients with sepsis
Large molecule removal

PRISMAFLEX: Continuous VenoVenous Haemofiltration (CVVH)



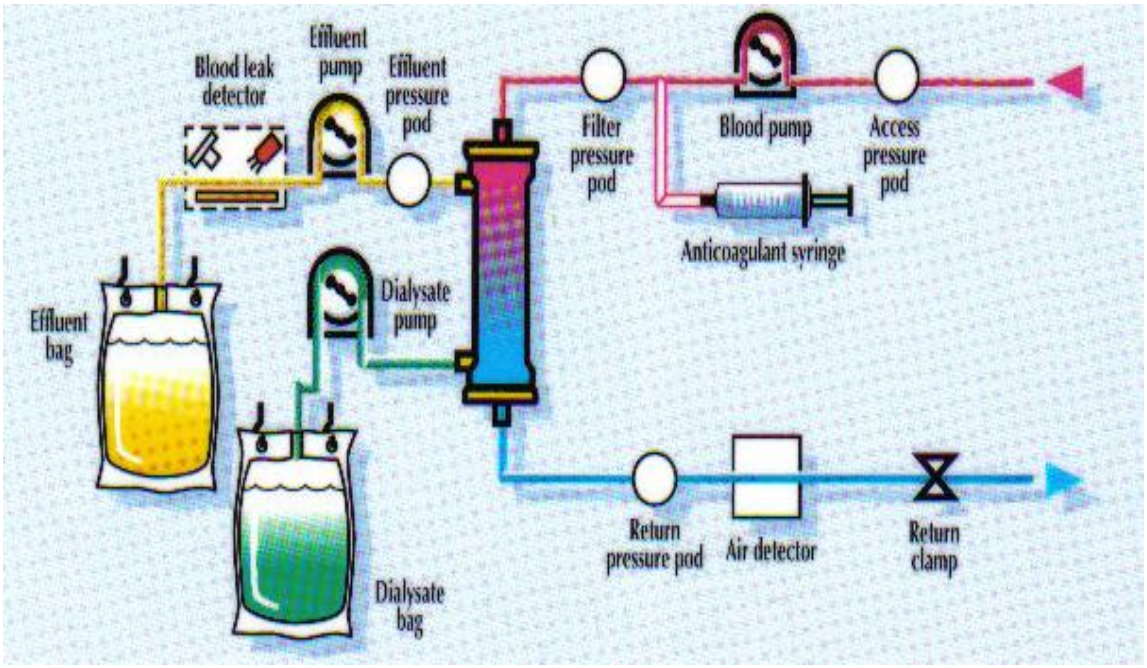
PRISMAFLEX Systems (2007). *An integrated system for continuous fluid management and renal replacement therapies: CRRT basics power point presentation, Sydney Australia.*

On the Prismaflex we have the ability to run replacement solution both pre and post filter. We would normally run the replacement solution post filter.

In addition, there is also the option of adding to the circuit the Pre Blood Pump dilution fluid.

Advantages:	Disadvantages:
○ Controlled fluid removal volumes ○ Effective clearance of large solutes ○ Maintains cardiovascular stability	○ Requires anticoagulation ○ Requires venous access ○ Requires specialised staff ○ Requires hospitalisation ○ **Requires replacement fluid**

PRISMA: Continuous VenoVenous Haemofiltration (CVVHD)

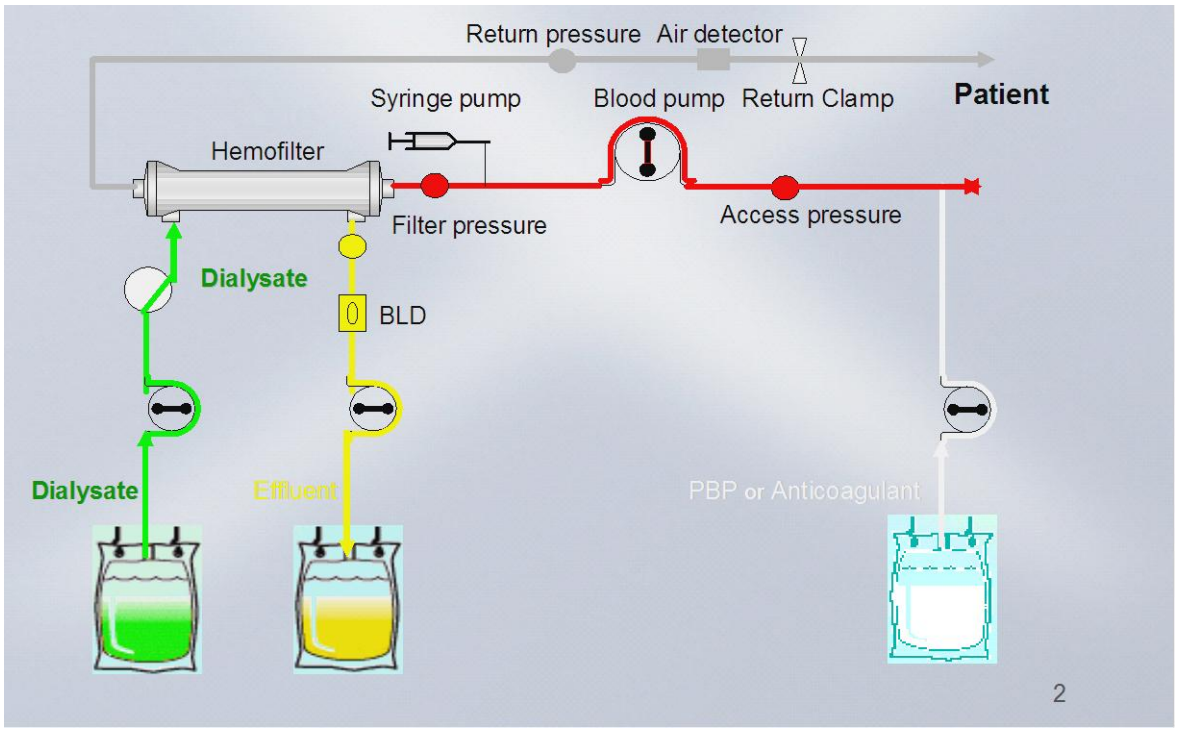


PRISMA Systems (2000). *An integrated system for continuous fluid management and renal replacement therapies: Operator's Manual.* Basel, Switzerland: HOSPAL AG.

In CVVHD a dialysate solution 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 haemodialysis. 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

Uses:
Diffusion
Ultrafiltration
Minimal adsorption.
Treatment of patients with Acute Renal Failure (ARF) but without sepsis
Small molecule removal

PRISMAFLEX: Continuous VenoVenous Haemofiltration (CVVHD)

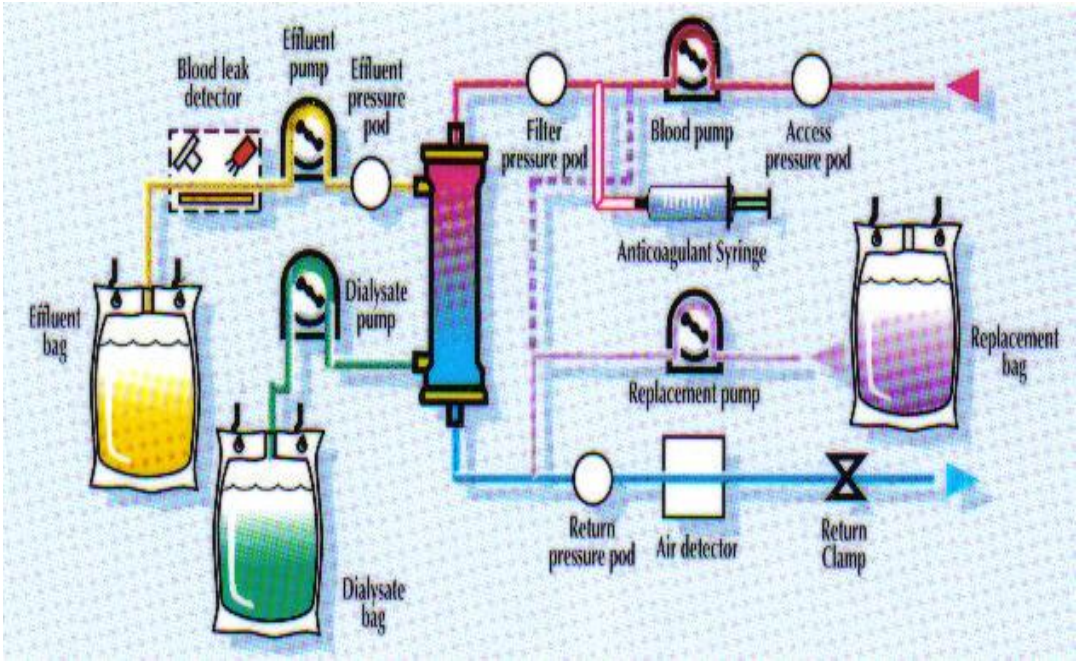


PRISMAFLEX Systems (2007). *An integrated system for continuous fluid management and renal replacement therapies: CRRT basics power point presentation, Sydney Australia.*

On the Prismaflex the only additional line is the PBP which predilutes the blood prior to it reaching the filter. This helps to improve the filter life.

Advantages:	Disadvantages:
○ Convective and diffusive clearance ○ Controlled fluid removal ○ Slow correction of electrolyte and acid/base derangements ○ Moderate cost ○ Good small solute removal	○ Requires anticoagulation ○ Requires venous access ○ Requires specialised staff ○ Requires hospitalisation ○ **Requires dialysate fluid**

PRISMA: Continuous VenoVenous Haemofiltration (CVVHDF)

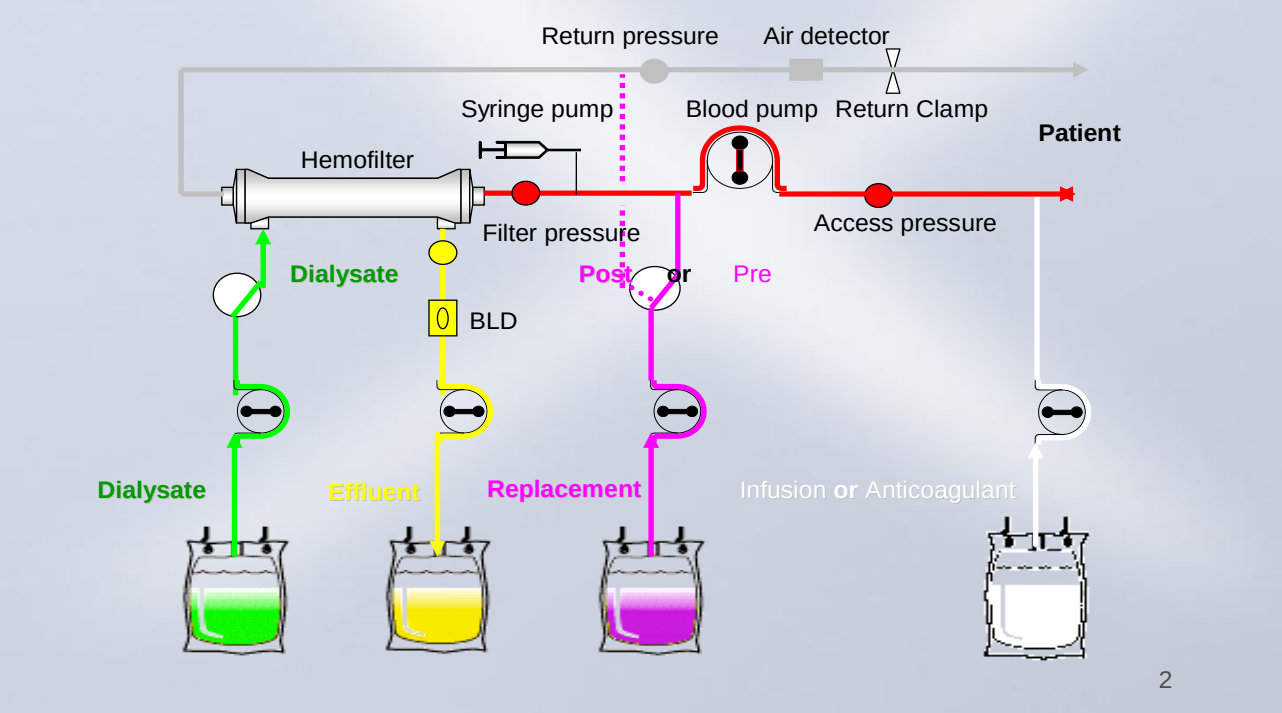


PRISMA Systems (2000). *An integrated system for continuous fluid management and renal replacement therapies: Operator's Manual.* Basel, Switzerland: HOSPAL AG.

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.

Uses:
Diffusion
Convection
Adsorption
Ultrafiltration
Treatment for patients with ARF
Multiple Organ Dysfunction Syndrome (MODS)
Sepsis
Small and large molecule removal

PRIMSAFLEX: Continuous VenoVenous HaemoDiafiltration (CVVHDF)



PRISMAFLEX Systems (2007). *An integrated system for continuous fluid management and renal replacement therapies: CRRT basics power point presentation, Sydney Australia.*

On the Prismaflex the PBP runs pre-filter and the replacement solution is set to run post filter.

Advantages:	Disadvantages:
○ Rapid controlled fluid removal ○ Large diffuse volumes ○ Rapid correction of electrolyte and acid/base derangement ○ Immediate, effective clearance of small molecules ○ Most widely used form of dialysis in ICU	○ Requires anticoagulation ○ Requires venous access ○ Requires specialised staff ○ Requires hospitalisation ○ Tends to have a negative impact on cardiovascular functioning (↓BP) ○ **Requires dialysate and replacement fluid** ○ Slower clearance of large molecules ○ Moderately expensive

Short Term High Volume HaemoFiltration (STHVH)

This is a newer mode of dialysis and is not commonly used as most machines are not able to set the flow rates at a high enough rate (ml/hr). It is able to perform up to 15 litre exchanges an hour. It requires a special filter that can cope with the high flow rates as well as a larger access cannula.

It is used in specialised renal units.

Advantages

- Short term treatment in emergency situations (4 hours)
- Uses very large exchange volumes
- Good clearance of small and large molecules
- Good clearance of septic mediators
- Controlled fluid removal

Disadvantages

- Requires anticoagulation
- Requires large venous access
- Very specialised staff
- Expensive
- Requires dialysate and replacement fluid
- Specialised machine
- Normally requires cardiovascular and respiratory support during treatment

Pre or Post dilution?

Often depends on the type of machine and the filters available.

Predilution

- ↑ rate of filtration and convection
- ↓ rate of diffusion (↓ concentration gradient)
- ↓ blood viscosity and therefore aids in extending the filter life
- Increases urea clearance by up to 20% because of a reduction in plasma oncotic pressure

Postdilution

- Primarily replaces fluid and electrolyte losses
- No solute dilution
- Increased Haemoconcentration

Therapeutic Plasma Exchange

- Also know as plasmapheresis. Used to remove blood-borne disease mediators which reduce the severity and duration of illness (eg GBS). It uses the principle of removing the patient's plasma through the use of a filter that is only permeable to plasma. The patient's plasma is simultaneously replaced with Fresh Frozen Plasma and Albumin. It is usually runs for several hours and over a couple of consecutive days

- Can be performed on the Prisma and Prismaflex machines.
- Requires anticoagulation.
- Requires a replacement solution – either Albumin or Fresh Frozen Plasma.
- Special filters used to separate and remove plasma from the blood.

At Hornsby Hospital ICU we have separate policies and observation charts which need to be used for TPE. Please ensure these are accessed if TPE is being performed.

Charcoal Haemoperfusion

- The original form of dialysis using a filter.
- Is still used in specific overdose cases that will not respond to conventional dialysis.
- Uses a special charcoal filter that absorbs specific drugs and their by-products.
- Only modern machine capable of performing function.
- Requires specialised staff, who are trained in Charcoal Haemoperfusion
- Performed in emergency situations.
- The AK10 machine is no longer available. While we do have the appropriate software on the Prismaflex machine, it has not yet been activated. We do not stock the lines or filters required, however these can be accessed from the supplier directly should the software be activated.

Gambro AK10 dialysis machine used for Charcoal Haemoperfusion

Nursing Care of a Patient on CRRT

The 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 WCC 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 fibres, 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-volaemic; 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 tachyponea, distress, fatigue and signs of infection (regular sputum samples sent for culture). Such monitoring is essential to discover or prevent the development of pulmonary oedema or pleural effusions. For patients that are requiring non invasive 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 vascath 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 vascath 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 vascath side will often occlude the vascath as the increased pressure causes the vascath to be advanced slightly. Patients still need to be turned at least every 2nd hour 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. (See section on Anticoagulant Therapies and also Hornsby Hospital ICU Heparin protocol).

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 dialysed 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 dialysed 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.

Trouble shooting

The interruption of the dialysis machine for any period of time will adversely affect the life of the circuit. Trouble-shooting 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.

Some useful troubleshooting tips in the event of high access/return pressures:

a. Reposition the patient / check that the patient is adequately sedated - if appropriate.
b. Ensure that none of the lines are kinked or clamped.
c. Swap the access and return lines on the vascath and assess if this rectifies the problem (this may reduce clearance rates but by <5%).
d. Turn/rotate the vascath within the vessel (you will need to take down the dressing to do this but you will NOT need to remove the sutures).
e. As a last resort to prolong the filter life the blood rate may be lowered and the replacement rate lowered as well - this will need to be ordered by the Registrar or Intensivist. This may provide adequate time to set up for returning the blood to the patient.
f. Assess the pressure pod readings and adjust as per the Prisma manual-
    i. On negative pods - add up to 1ml of normal saline
    ii. On positive pods – remove 1ml of normal saline

    This may need to be done when self test fails - see flow chart at back of manual and attached to machine. This is called “repositioning the pressure membrane”.

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.

Alternative Anticoagulants Therapies

- Heparin/Protamine Regional Therapy,
- Low Molecular Weight Heparin (LMWH),
- Citrate,
- Prostacyclin, and
- No anticoagulation at all.

1. Heparin/Protamine Regional Therapy is beneficial in patients where bleeding is a concern. A heparin infusion is run pre-filter to anticoagulate the circuit, and then protamine is run post-filter to reverse the effects and prevent systemic anitcoagulation. Protamine is a basic protein that combines with heparin to form a stable inactive complex. This therapy would be one of the better alternatives because it reduces the risk of bleeding and prevents systemic anticoagulation. Also, it is possible to perform on the PRISMA machine and with the level of nursing skills available.

2. LMWH inhibits Factor Xa, and this reduces thrombin and thrombus formations. It does this by inhibiting the normal clotting cascade determined by PTT. LMWH's main side effects are that it has a prolonged half-life (>10hours) and it is not totally reversed by protamine. Studies have shown it has reduced bleeding-enhancing activity with no significant changes in filter life when compared to full heparinasation. However, it does require specialised blood measurements, such as the anti-FXa activity, which are not always readily available.

3. Citrate anticoagulates by chelation of ionized calcium. It is added pre-filter in the form of trisodium citrate, and is neutralised by a post-filter infusion of calcium chloride. It does not cause systemic anticoagulation. It has excellent filter patency, lasting longer than full heparinisation, but citrate requires a diffusive component and specialist replacement and dialysate fluids. It is a very expensive and labour-intensive method of anticoagulation, when compared with full heparinisation.

4. Prostacyclin prevents platelet adhesion and aggregation, and this protects the filter from clotting. Prostacyclin causes systemic anticoagulation, as well as anticoagulation of the circuit. It prolongs the anti-platelet effect with no reversing agent. It is difficult to monitor and has an increased risk of hypotension and bleeding. It is indicated for patients with a Heparin Induced Thrombosis - Thrombocytopenia (HITTs).

5. Haemofiltration with no anticoagulation can be a beneficial method for a patient with an increased risk of bleeding. The circuit life is decreased by about two hours, when compared to the use of LMWH. Clearance rates are good and there are few side effects for the patient. The use of replacement fluid to dilute the blood pre-filter has been shown to aid in maintaining the circuit life.

References:

1. Caswell, A. (1999). *MIMS Annual, Australia (23rd ed)*, Sydney, Australia: MediMedia Australia.
2. Elliot, R. (2004). *The care of the patient receiving continuous renal replacement therapy*. Royal North Shore Hospital CRRT protocol and guidelines. Sydney, Australia: RNHS.
3. Forni, L & Hilton, P. (1997). *Current concepts: continuous hemofiltration in the treatment of acute renal failure.* New England Journal of Medicine. Vol 336(18), 1303-1309.
4. Griswald, W., Reznik, V., Lemire, J., Benador, N., McDonald, D. & Metha, R., (1998*). Regional citrate anticoagultion for continuous venovenous hemodiafiltration in critically ill children with acute renal failure.* International Pediatric research Foundation. Vol 43(4), supplement 2, 308.
5. Kaplan, A. (1998). *Continuous renal replacement therapy (CRRT) in the intensive care unit*. Journal of Intensive Care Medicine. Vol 13(2), 85-100.
6. Kaplow, R. & Barry, R. (2002). *Continuous renal replacement therapies: a more gentle blood filtering technique allows for fewer complications.* American Journal of Nursing. Vol 102(11), 26-33.
7. Lameire, N. &Vanholder, R. (2000). *New perspectives for prevention/treatment of acute renal failure* Current option in Anaesthesiology Vol 13(2), 105-112.
8. Mehta, R., McDonald, B., Aguilar, M. & Ward, D. (1990). *Regional anticoagulation for continuous arteriovenous hemodialysis in critically ill patients*. Kidney International. Vol 38, 976-981.
9. Morabito,S., Guzzo, I., Solazzo, A., Muzi, L., Luciani, R. & Pierucci, A. (2003). *Continuous renal replacement therapies: anticoagulation in the critically ill at risk of bleeding*. Journal of Nephrology. Vol 16(4), 566-571.
10. Palsson, R. & Niles, N. (1999). *Regional citrate anticoagulation in continuous venovenous hemofiltration in critically ill patients with a risk of bleeding.* Kidney International. Vol 55(5), 1991-1997.
11. Paton, M. (2003). *Continuous renal replacement therapy: slow but steady.* Nursing2004. Vol 33(6), 48-50.
12. Powel, V., Peterson, B. & Griswald, W. (1999). *Continuous venovenous hemodiafiltration with citrate anticoagulation in critically ill pediatric patients*. Critical Care Medicine. Vol 27(1S), 61A.
13. PRISMA Systems (2000). *An integrated system for continuous fluid management and renal replacement therapies: Operator's Manual.* Basel, Switzerland: HOSPAL AG.
14. Silvester, W., Bellomo, R. & Cole, L. (2001). *Epidemiology, management and outcome of severe acute renal failure of critical illness in Australia.* Critical Care Medicine. Vol 29(10). 1910-1915.
15. Sole, M., Lamborn, M. & Hartshorn, J. (2001). *Introduction to critical care nursing* (3rd ed), Pennsylvania, USA: W.B. Saunders.
16. Uchino, S., Fealy, N., Baldwin, I., Morimatsu, H. & Bellomo, R. (2004). *Continuous venovenous hemofiltration without anticoagulants*. American Society of Artificial Internal Organs Journal. Vol 50(1), 76-80.
17. Urden, L., Stacy, K., & Lough, M. (2002). *Thelan's critical care nursing: Diagnosis and management* (4th ed). 763-770. St Louis, USA: Mosby.
18. Weems, Janice *1991 Quick Reference to Renal Critical Care Nursing*. Aspen Publishers Inc. U.S.A
19. McCance and Huether *2004 Pathophysiology The biologic basis fro disease in adults and children 4th edition,*
20. Tortora and Grabowski 1993 *Principles of Anatomy and physiology* John Wiley and Sons Inc
21. McCance and Huether 1994. *Pathophysiology: The biological Basis for Disease in Adults and Children*, Mosby-Year Book, Inc.
22. Oh, T.E. 1997. *Intensive Care Manual* , Reed Educational and Professional Publishing Ltd.
23. Tortora and Grabowski, 1993. *Principles of Anatomy and Physiology*, HarperCollins College Publishers.

Continuous Renal Replacement Therapy Worksheet

1. What is the major difference between the haemodialysis used in renal clinics and that used in Intensive Care?

2. List five reasons for instituting Continuous Renal Replacement Therapy (CRRT)?

3. Briefly describe the principle of diffusion.

4. Briefly describe the principle of Ultrafiltration.

5. Explain what is meant by the term convection?

6. Explain the term “counter current” flow, why is it beneficial?

7. Why do we heat the dialysate fluid and NOT the replacement fluid?

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

9. Why does the patient on CRRT require anticoagulation?

10. What is the purpose of the air detection system and clamp found on the return line of the PRISMA machine?

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

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

13. How often should the filter and lines be changed and why?

14. List the potential complications of CRRT?

15. What does the APTT test check?

16. The Prisma machine has four pumps. Name them and describe their function.

17. Why are the dialysate, replacement and effluent bags hung on scales?

18. What is the purpose of “predilution”?

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

20. What is the function of the blood leak detector?

21. If the blood leak detector fails to “normalise” during the priming procedure what should you check?

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

23. Is it possible to interrupt CRRT on the PRISMA to send your patient to CT?

24. Briefly describe the procedure to return blood to the patient prior to ending treatment?

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

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

27. If the periodic “self test” fails- what action should be taken?

Continuous Renal Replacement Therapy (CRRT)

(Registered Nurse)

DESCRIPTOR: Demonstrates knowledge of the indications for CRRT, the ability to set up, maintain and remove a CRRT circuit, care for a patient receiving CRRT and troubleshoot a variety of problems related to the patient or CRRT circuit.

Candidate: _____ Assessor: _____

ELEMENTS (Expected Performance)	**PERFORMANCE CRITERIA** (Critical Aspects)
A Demonstrates awareness of infection control guidelines	1.1 Perform hand hygiene 1.2 Utilises relevant personal protective equipment (PPE) 1.3 Disposes of and/or returns equipment correctly
B Adheres to occupational health and safety standards	2.1 Creates a safe work environment 2.2 Adjusts bed height appropriately 2.3 Recognises and clears trip hazards 2.4 Disposes of equipment appropriately
1. Demonstrates awareness of the complications of CRRT.	1 Outlines the complications of CRRT.
2. Understands the mechanism of dialysis	1. Explains the principles of dialysis 2. Discusses the products that can be dialysed out of the body 3. Identifies the haemofiltration solutions used in this ICU. 4. Explains the main differences between the Prisma and Prismaflex machines.
3.Demonstrates the ability to set up and prime a CRRT circuit	1. Assembles equipment required for CRRT circuit including the emergency equipment required at the bedside. 2. Identifies the various pumps and filter pods on the machine that are being used 3. Explains the principle of TMP and how the calculation is made. 4. Discusses the pressures that can be expected and some possible ways to troubleshoot any abnormalities 5. Discusses the set flow rates and how these can be adjusted to improve the functioning of the circuit, removal of solutes and ensure appropriate running of the circuit.

4. Recognises the use of anti-coagulation in CRRT	1. Explains the rationale for and observations that are required when a patient is receiving anticoagulation therapy. 2.Outlines the types of anti-coagulation that are available. 3. Describes the advantages and disadvantages of 2 forms of anticoagulation. 4. Describes the correct connection of anticoagulation to the circuit.
5.Connects the patient to the circuit	1.Primes the circuit correctly, including connecting the warming circuit if required. 2.Explains the process to connect a patient to the circuit 3.Connects dialysis successfully to the patient
6. Competently manages a patient on CRRT	1.Explains the observations attended for the patient 2.Demonstrates the care of the vascath 3.Outlines the treatment of hypothermia 4.Discusses the methods of controlling the fluid balance for the patient both on the CRRT chart and the measures on the machine 5.Is able to troubleshoot some alarms for the Prisma and Prismaflex machines including: dialysis, effluent, replacement weight , PBP and disconnection alarms. Explains the light system.
7. Documents observations/interventions appropriately	1.Identifies the correct chart and documentation required 2.Can explain what documentation should occur: • the use of the default orders • patient care plan • CRRT chart
8. Demonstrates safe removal of CRRT	1.Explains the process of “running the patient off” the CRRT circuit. 2.Explains when to return the blood and when not to and the rationale behind these. 3.Demonstrates the ability to do this procedure in a safe & timely manner 4.Explains the process of the recirculation procedure

<table>
<tr><th>EVIDENCE GUIDE</th><th>ASSESSMENT DECISION</th></tr>
<tr><td>Context for assessment:
This unit of competency must be assessed in the workplace, if possible after the completion of the CRRT learning package</td><td>☐ Competent ☐ Not Yet Competent</td></tr>
<tr><td>Range of variables:</td><td>Action/Further Training Required:</td></tr>
<tr><td rowspan="4">Underpinning knowledge is required
of the following:
Hospital Policy
Standard Precautions
OH&S Standards
Relevant anatomy and physiology</td><td>Details of Feedback to Candidate:</td></tr>
<tr><td>Details of Feedback from Candidate:</td></tr>
<tr><td>Assessor’s Signature:

Date:</td></tr>
<tr><td>Candidate’s Signature:

Date:</td></tr>
</table>

Assessment Matrix

Methods used to gather evidence	*Elements of Competency*							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Observation			√	√	√	√	√	√
Oral Questioning	√	√	√		√		√	√
Confirmation of Result	√	√		√		√	√	