Continuous Renal Replacement Therapy (Adults) Learning Package

Intensive Care Services
John Hunter Hospital

Name:_____

NSW GOVERNMENT Health
Hunter New England
Local Health District

Document Authorisation

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Document no.	1

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Disclaimer

This learning package has been prepared by health care professionals employed in the intensive care unit at the John Hunter Hospital. While all care has been taken to ensure that the information is accurate at the time of development, the intensive care unit at the John Hunter Hospital recommends that all information is thoroughly checked before use if utilised in another unit, context or organisation.

Feedback

This learning package has been added to the intensive care unit intranet (help library) for all to view. We appreciate feedback and encourage you to contact the primary author via e-mail (this is located in the authorisation table on the previous page). The primary author may also be prepared to provide further information and insights to the topic.

Introduction

This learning package provides an overview of acute renal failure and its complications. The learning package will also facilitate the Registered Nurse and Doctor's understanding of the principles of Continuous Renal Replacement Therapy (CRRT). It is to be used in conjunction with the related John Hunter Hospital CRRT guidelines and procedures. These guidelines and procedures can be accessed from the intensive care intranet.

Learning outcome objectives (for Registered Nurses)

Completion of this learning package will enable the Registered Nurse to complete the related CRRT competencies, and therefore demonstrate an understanding of the following:

- Understanding of acute renal failure
- Indications for CRRT
- Describe the different modes of CRRT used for the critically ill patient
- Anti-coagulation
- Identify potential complications of haemodiafiltration
- Nursing management of patient receiving CRRT

Prerequisites

In order to complete this package the registered nurse must have met the following requirement:

- Successful completion of Step 1 & 2 of the *Professional Development Pathway* for intensive care nurses at John Hunter Hospital

Recognition of prior learning

Relevant postgraduate qualification will be acknowledged e.g. Graduate Certificate in Critical Care. RPL will be granted at two levels:

1. Registered Nurses who have completed relevant post graduate qualifications will not have to complete this package
2. Registered Nurses who have completed relevant post graduate qualifications and can provide supporting documentation of CRRT competency assessment will not have to complete this package or the CRRT competency

If you feel that you hold relevant qualifications please speak with a member of the ICU Education team.

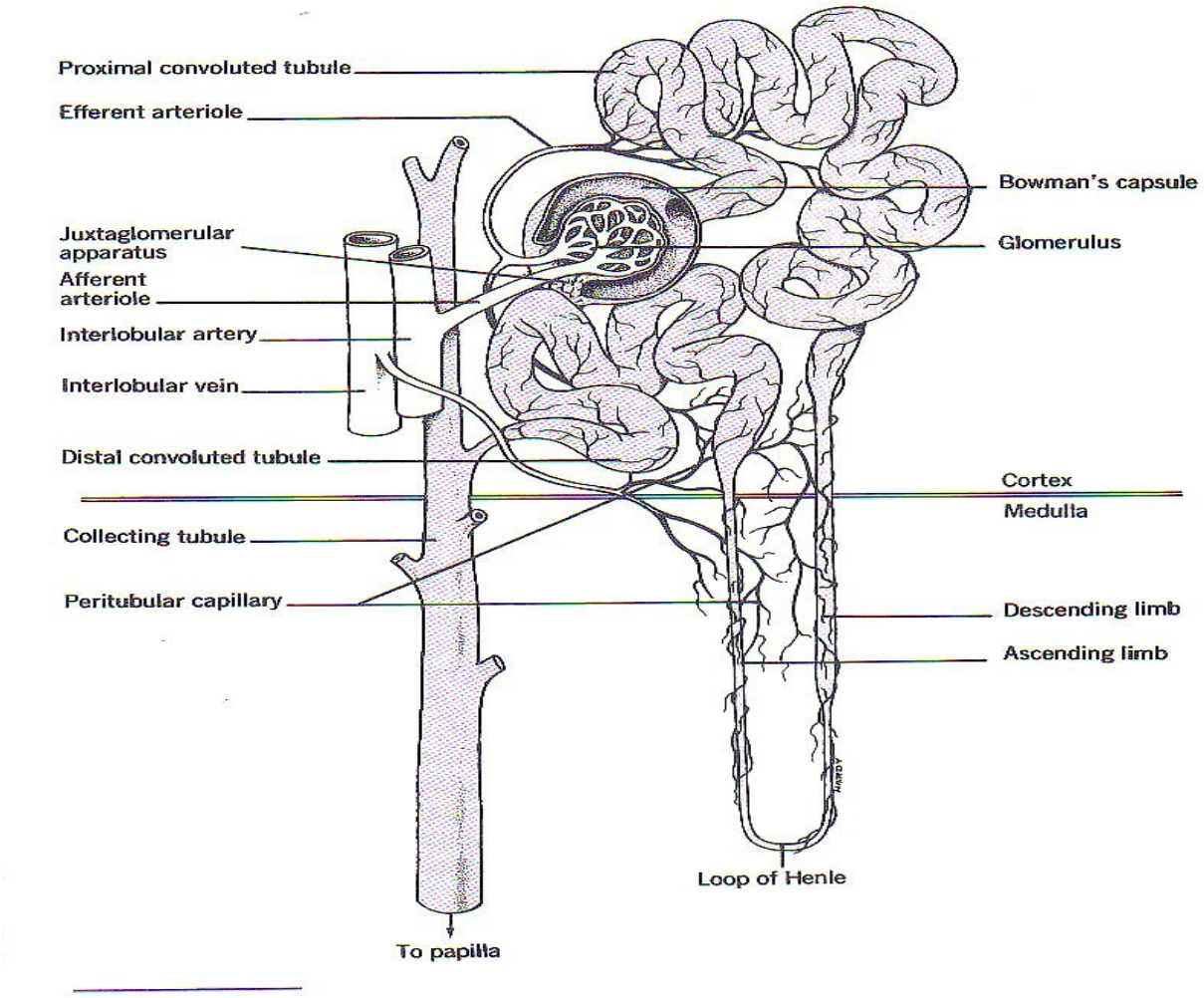
Assessment process

Following completion of this package please give it to an accredited assessor for review. Following this review the Registered Nurse and Doctor can commence caring for a patient receiving CRRT and complete the intensive care CRRT competency with an accredited assessor.

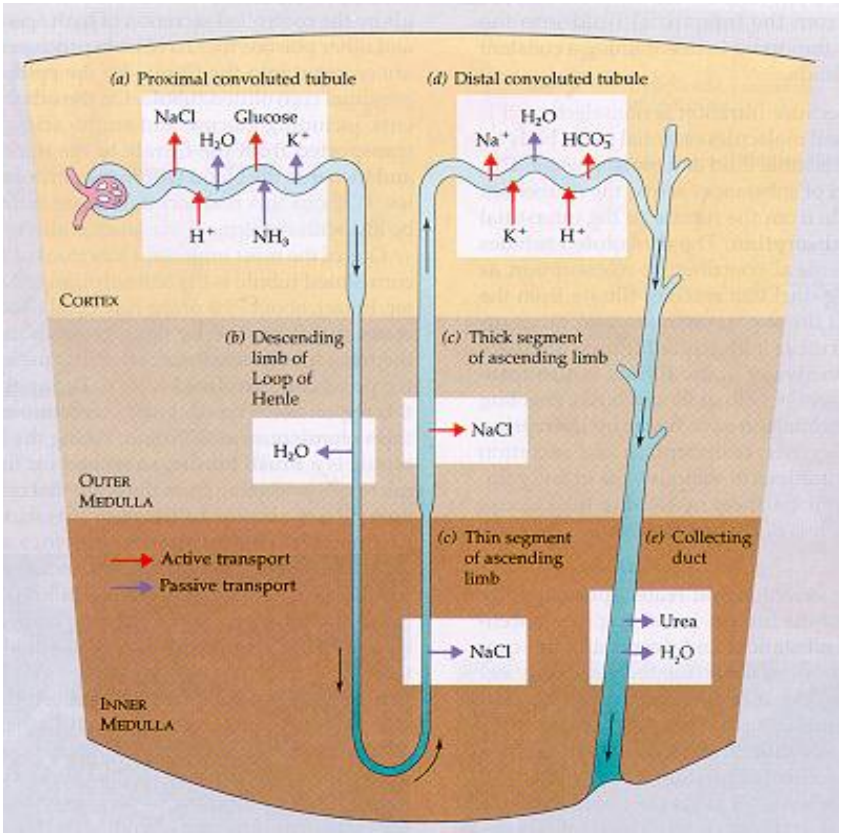
Acute Renal Failure

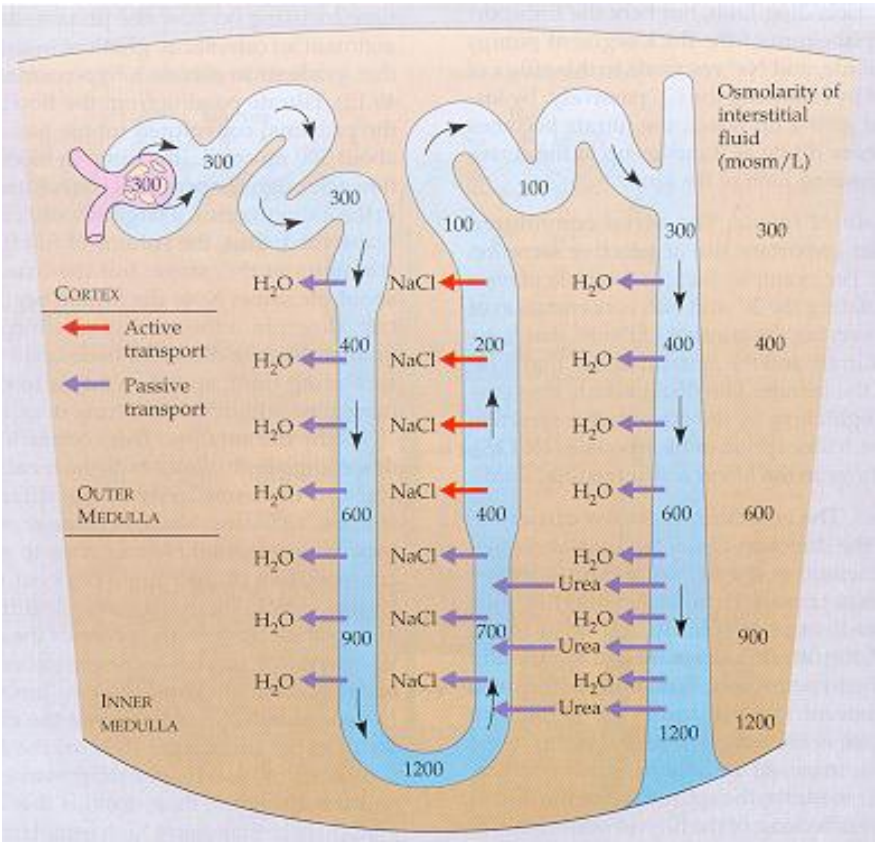
Acute renal failure (ARF) is a common manifestation of critical illness and is often associated with multi organ failure. While in many cases reversible, ARF can be life threatening in the critically ill patient if acid – base imbalance, fluid overload and electrolyte levels are altered and not effectively managed (Baldwin & Leslie, 2007). ARF is also referred to as Acute Kidney Injury or Insufficiency (AKI) and is diagnosed using the 'Rifle' criteria (Martin (2010).

ARF is the abrupt reduction of renal function with progressive retention of metabolic waste products. ARF is best understood when the condition is considered in terms of the location of damage to the renal system: i.e. pre-renal, intra-renal, or post-renal causes of renal failure.



The Nephron (Hudak,Gallo,Morton. Critical Care Nursing, a holistic approach 1997)





The functioning nephron. oracle3927.tripod.com/nephron.htm

Types of Acute Renal failure (ARF)

Pre-renal failure

Physiologic conditions that lead to decreased perfusion of the kidneys without intrinsic damage to the renal tubules are identified as pre-renal failure. This decreased perfusion leads to a reduction in the blood filtration rate through the glomerulus and results in a reduced ability of the kidneys to filter waste products from the blood. Consequently, more sodium and water are reabsorbed leading to oliguria. If this is detected and managed early, the damage sustained from pre- renal failure is mostly reversible.
A decrease in renal blood flow and a fall in glomerular filtration rate may result from hypovolaemia, decreased cardiac output or altered peripheral vascular resistance.

Intra-renal (intrinsic) failure

Damage to the renal tubule, nephron or renal blood vessels and their function can be due to infective or inflammatory illness, toxic drugs, toxic wastes from systemic inflammation in sepsis, vascular obstructive thrombus or emboli.

Kidney failure persists following restoration of adequate renal perfusion or where no loss of perfusion has occurred and there is no obstruction to urine flow (Baldwin & Leslie 2012, in ACCCN's Critical Care Nursing)
The most common causes of this type of acute renal failure include:

- Glomerulonephritis
- Nephrotoxicity
- Vascular insufficiency

Acute Tubular Necrosis (ATN)

Intra-renal (intrinsic) ARF is often associated with underlying pathophysiologic abnormalities and is referred to as acute tubular necrosis (ATN).
ATN describes damage to the tubular portion of the nephron and may manifest in slight metabolic changes to total destruction of the cell structure. ATN is the causative mechanism for up to 30% of acute renal failure within the intensive care setting with multifactorial origins (Baldwin & Leslie 2012, in ACCCN's Critical Care Nursing).

Post-renal failure

Physiologic conditions, which partially or completely obstruct urine flow from the kidney to the urethral meatus, can cause post- renal failure. Partial obstruction increases renal interstitial pressure, which leads to an increase in the Bowman's capsule pressure and opposes glomerular filtration. Complete obstruction leads to urine backup, which compresses the kidney and results in a cessation of urine output from the affected kidney. Urinary tract obstruction can be caused by functional and mechanical factors such as nephrotoxic agents, clots, stones and tumours.

Aims of treatment

The broad aims of management for ARF are to:

- Restore and maintain systemic circulation and renal perfusion
- Promote urine production and flow
- Maintain appropriate fluid balance
- Monitor and manage electrolyte and acid base disturbances appropriately
- Support or replace renal function
- Avoid precipitating factors or ongoing insults e.g. unstable haemodynamics, nephrotoxic agents
- Modify nutrition to meet needs without further contributing to uraemia
- Monitor and treat complications of uraemia

Category	**GFR Criteria**	**Urine Output (UO) Criteria**	
Risk	Increased creatinine x1.5 or GFR decrease > 25%	UO < 0.5ml/kg/h x 6 hr	High Sensitivity
Injury	Increased creatinine x2 or GFR decrease > 50%	UO < 0.5ml/kg/h x 12 hr	
Failure	Increase creatinine x3 or GFR decrease > 75%	UO < 0.3ml/kg/h x 24 hr or Anuria x 12 hrs	High Specificity
Loss	Persistent ARF = complete loss of kidney function > 4 weeks		
ESKD	End Stage Kidney Disease (> 3 months)		

RIFLE Criteria for Acute Renal Dysfunction www.medicalcriteria.com/criteria/neph_rifle.htm

CRRT

Continuous renal replacement therapy is any extracorporeal blood purification therapy used to substitute impaired renal function for an extended period of time, and is intended to run for 24 hours a day (Bellomo, Baldwin,Ronco & Golper, 2002). Haemodialysis, haemofiltration and haemodiafiltration are three common methods used to achieve artificial kidney support in acute renal failure. This includes therapies that remove fluid, electrolytes, metabolic wastes and middle molecules from the circulation intermittently or continuously, via a filter.

CRRT involves the removal of water and solutes from the blood across a semi-permeable membrane via convection, diffusion and ultrafiltration. Varying rates of fluid and solute removal (ultrafiltrate) can be achieved through a variety of circuit and equipment set-ups, and applying different levels of hydrostatic and solute movement forces.

Indications for CRRT

- Metabolic acidosis
- Hyperkalaemia
- Renal failure with rising electrolytes where intermittent haemodialysis or peritoneal dialysis is not appropriate
- Diuretic resistant fluid overload
- Drug overdose

CRRT may also be considered to support patients who have:

- Acute severe hepatic failure
- Septic shock (may change the profile of septic mediators)
- Myoglobinuria-crush syndrome

Intermittent haemodialysis is a recognised supportive therapy for renal failure. However, cardiovascular instability is a potentially serious problem when haemodialysing the critically ill patient already compromised by hypotension. Haemofiltration offers greater cardiovascular stability in particular veno-venous haemofiltration (Baldwin & Leslie 2007).

Therefore CRRT allows:

- Continuous gentle fluid removal: achieving an accurate fluid balance and avoiding haemodynamic instability
- Removal of toxic waste products: urea, creatinine, drugs
- Correction of electrolyte and acid base disturbances

Definition of Terms

Adsorption
Is the removal of solutes from the blood because they cling to the haemofilter membrane

Concentration gradient
The difference in concentration of molecules between two fluids (e.g. blood and dialysate)

Hydrostatic pressure
Refers to the pressure applied to the membrane by a liquid i.e. blood that determines the movement of water across the membrane

Oncotic pressure
The oncotic pressure is directly related to components too large to be filtered, e.g. albumin and other plasma proteins. The higher the concentration of molecules in the plasma, the greater the oncotic pressure. As a result filtration decreases, as the concentration of molecules in the blood increases

Solute
A substance dissolved in a fluid or solvent to form a solution. A solution consists of a solute and a solvent

Solvent
A substance, usually a liquid which dissolves or is capable of dissolving solutes

Semi permeable membrane
A membrane permitting the passage of water and some small molecules, and hinders the passage of larger molecules

Dialysate
The solution administered into the ultrafiltrate-dialysate compartment of the haemofilter or haemodialyser in order to achieve solute clearance via diffusion

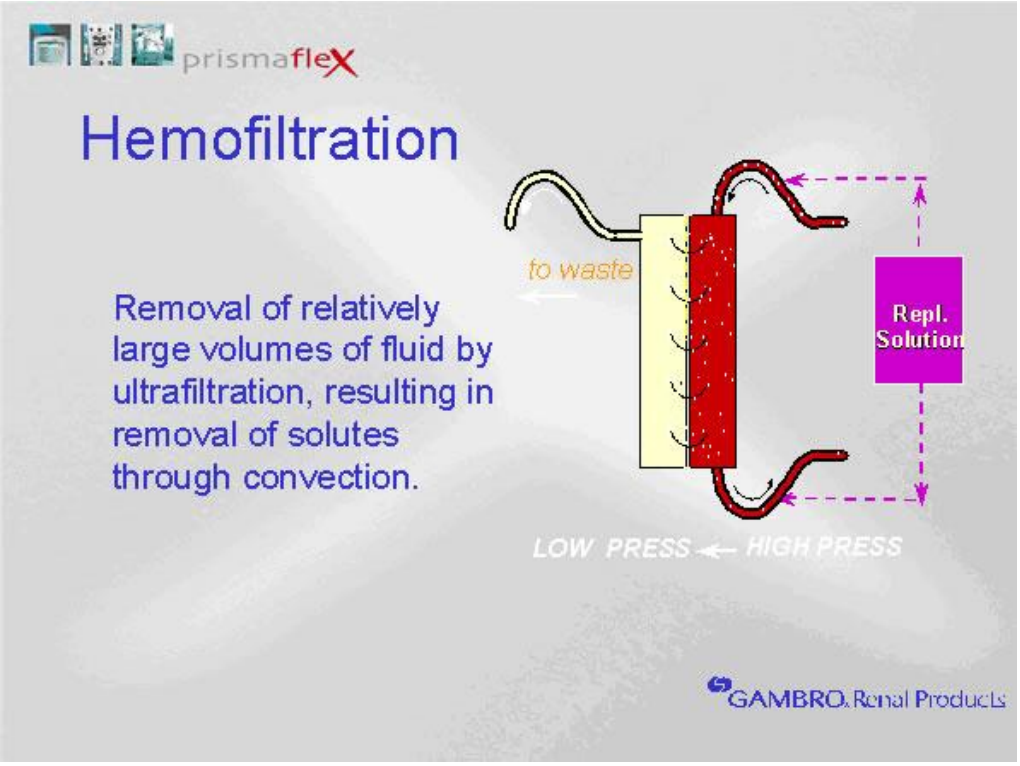
Replacement fluid
The fluid administered to the blood side of the haemofilter during haemofiltration to replace plasma volume lost during therapy. The electrolyte concentration and osmolality is similar to human plasma. This may be administered pre-filter or post- filter

Pre-dilution
The administration of replacement fluid into the patient's blood proximal to the haemofilter

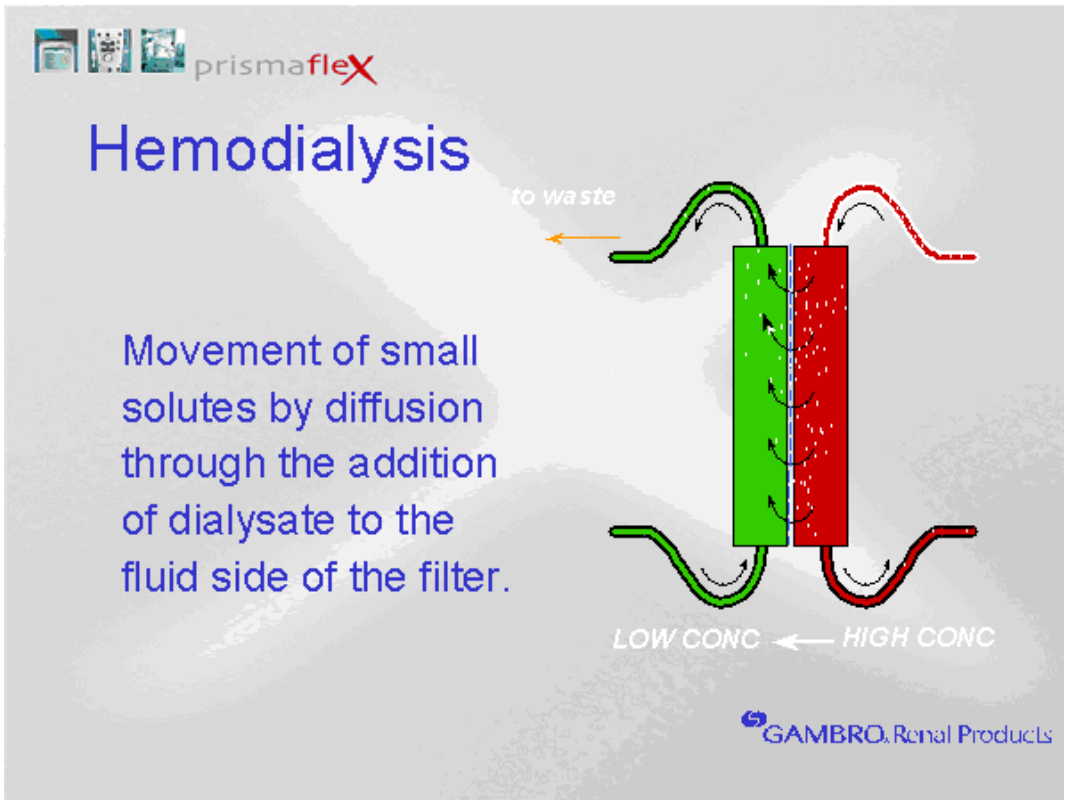
Post-dilution
The administration of replacement fluid into the patient's blood distal to the haemofilter

Ultrafiltrate
The net amount of water, solutes and wastes that are removed from the patient through the haemofilter and drained into a bag

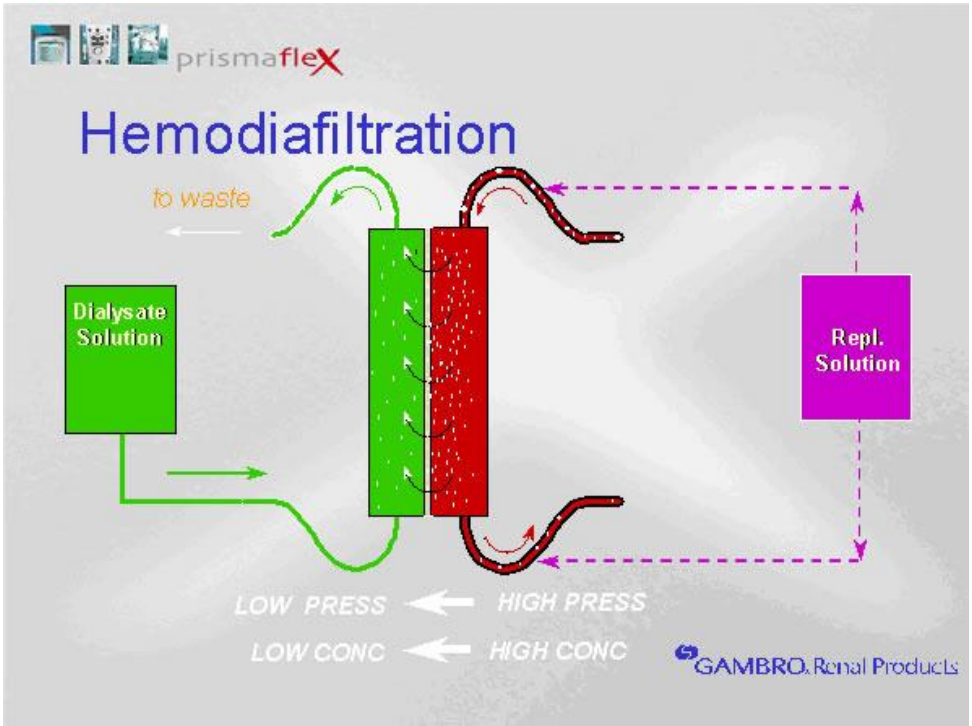
Haemofiltration
Haemofiltration mimics glomerular filtration, water is forced through a semi permeable membrane by hydrostatic pressure, drawing solutes by convection



Haemodialysis
Haemodialysis provides solute removal by diffusion and fluid removal if desired



Haemodiafiltration
Haemodiafiltration provides solute removal by a combination of diffusion and convection simultaneously, ultrafiltration and fluid removal if desired

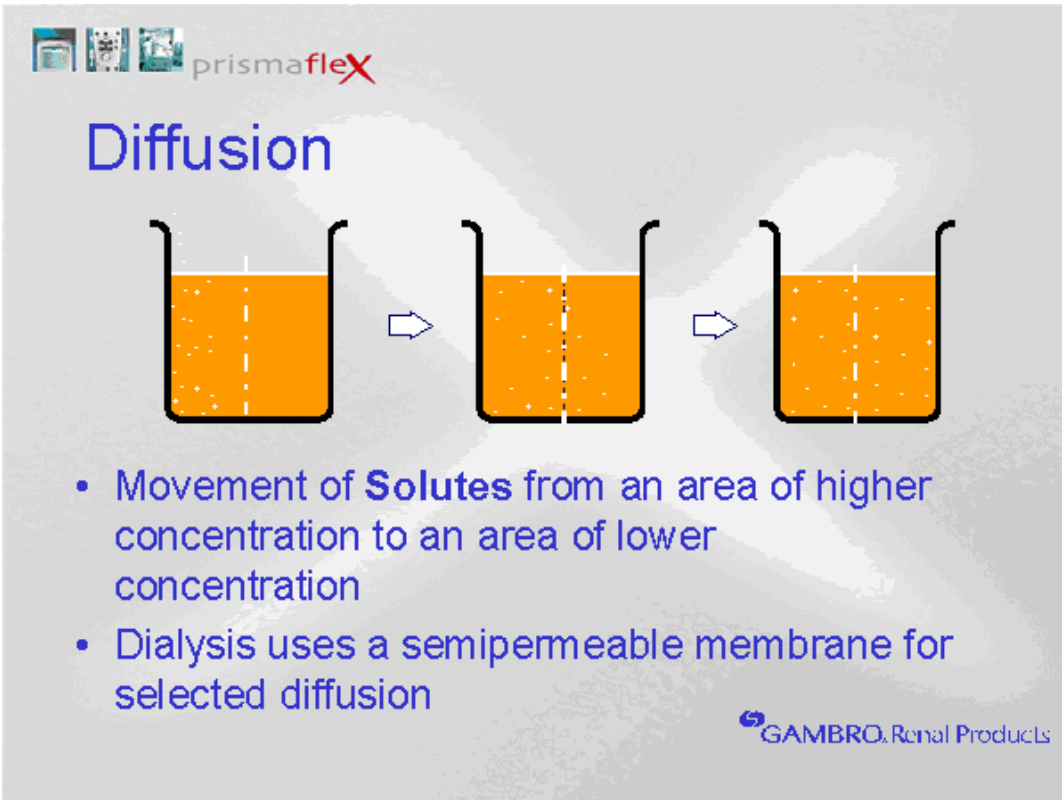


Principles of Dialysis

Diffusion

Diffusion refers to the movement of solutes from an area of high solute concentration to an area of low solute concentration across a semipermeable membrane. Diffusion is directly proportional to the concentration gradient, temperature and surface area. It is inversely proportional to the thickness of the membrane and proportional to the diffusion coefficient (Bellomo & Ronco, 2002).

Diffusion will continue until the concentration of the solute is equal on both sides of the membrane. It occurs within the haemofilter when a concentration gradient exists between the patients blood and dialysis fluid. As blood passes by the dialysis membrane, dialysate fluid is exposed to the blood on the opposing side of the membrane fibre (Baldwin & Leslie 2007).



Diffusion is increased by:

- Increasing the rate of the dialysate flow and
- Increasing the rate of blood flow

- Using countercurrent flow (using dialysate flow countercurrent to blood flow)
- Adjusting the 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 and
- Decreasing the rate of blood flow
- Dilution of the blood before the filter (pre-dilution replacement fluid)
- Decreasing the surface area of the membrane

The process of solute removal alone is termed dialysis, and when used with blood the process is termed haemodialysis.

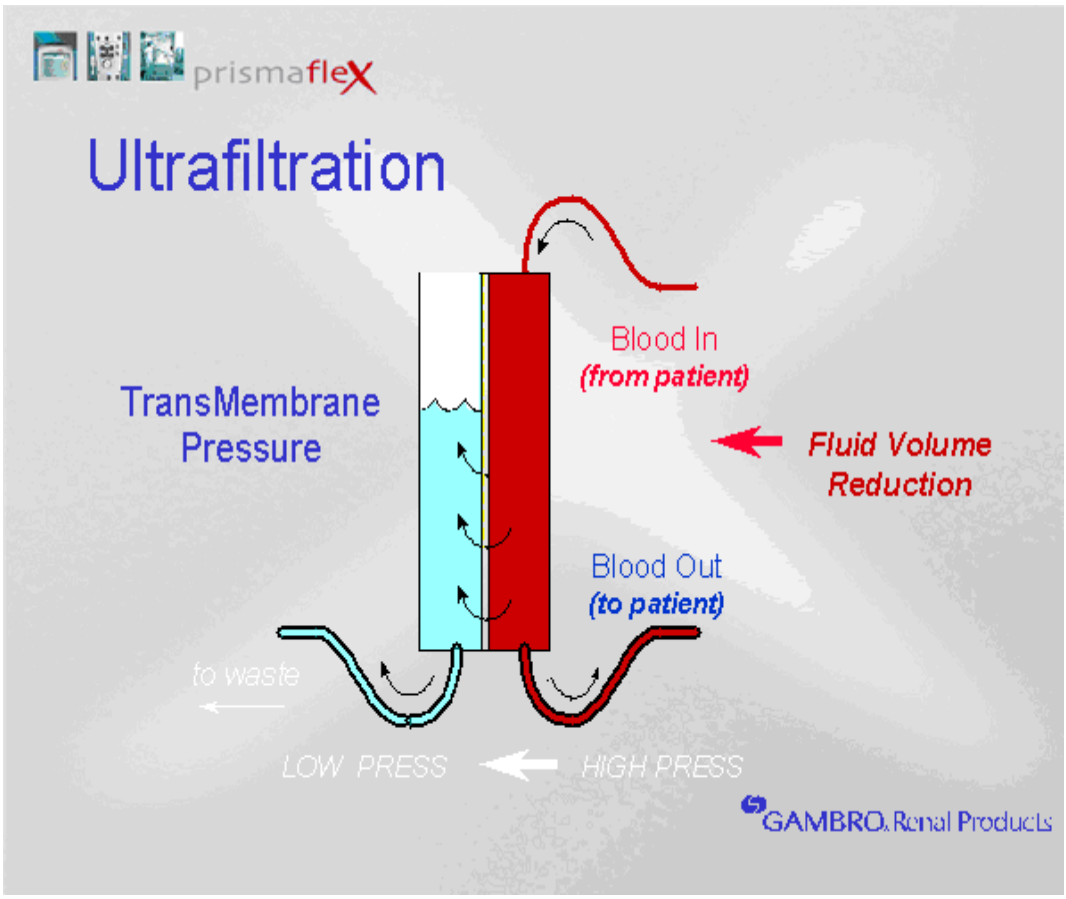
Convection

Convection is defined as a process of 'solute drag'. This solute drag is a result of flow, which occurs in response to a transmembrane pressure gradient. Dissolved solutes are removed with blood plasma as it is filtered through the semi permable membrane (Bellomo 2003). The size of the pores in the haemofilter membrane determines what solutes can be washed to the other side.

Convection mimics a kidney's glomerulus, as plasma is filtered across the nephron tubules via the Bowman's capsule. In CRRT, the plasma water with the dissolved wastes is discarded. The plasma deficit is then substituted with replacement fluid. This blood washing process is commonly known as haemofiltration.

Ultrafiltration

Ultrafiltration is the process, which allows the removal of plasma water, solutes and waste products from blood across a semi permeable membrane. This fluid is known as ultrafiltrate and is regulated by a trans-membrane pressure gradient achieved by the net difference between the hydrostatic and oncotic pressures (Bellomo & Ronco, 2002)



Both ultrafiltration and convection are increased by:

- An increase in positive pressure on the blood side of the circuit. This can be caused by either an increase in blood flow or an increase in the flow of pre-dilution replacement fluid (transmembrane pressure will increase due to the increase of volume "squeezing" through the haemofilter).
- An increase in negative pressure on the ultrafiltrate side of the membrane (filtrate is being "sucked" at a greater rate from the haemofilter).

Both 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 ultrafiltrate pump.

Now read the following journal article

Chrysochoou, G., Marcus, R.J., Sureshkumar, K.K., McGill, R.L., & Carlin, B. (2008) Renal Replacement Therapy in the Critical Care Unit. *Critical Care Nurse Quarterly, 31, (4)*, 282-290

This journal article can be obtained via the CIAP portal.

After reading this journal article complete the following:

In your own words, describe your understanding of the following terms

Haemodialysis

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Haemofiltration

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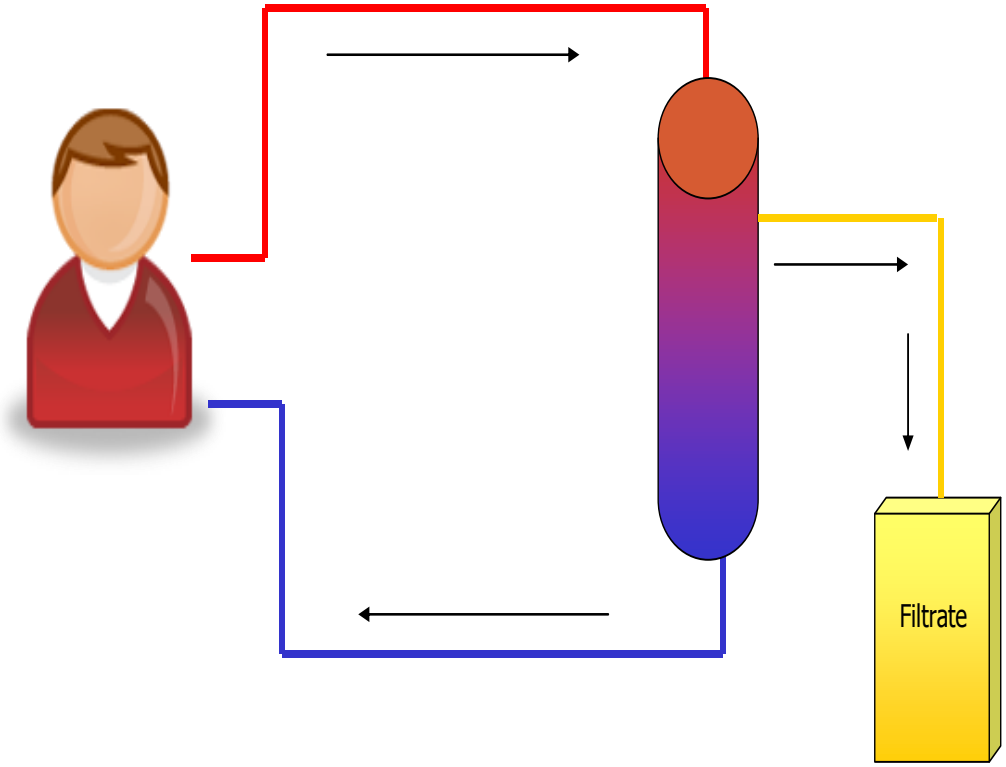
Modes of CRRT

Slow Continuous Ultrafiltration (SCUF)

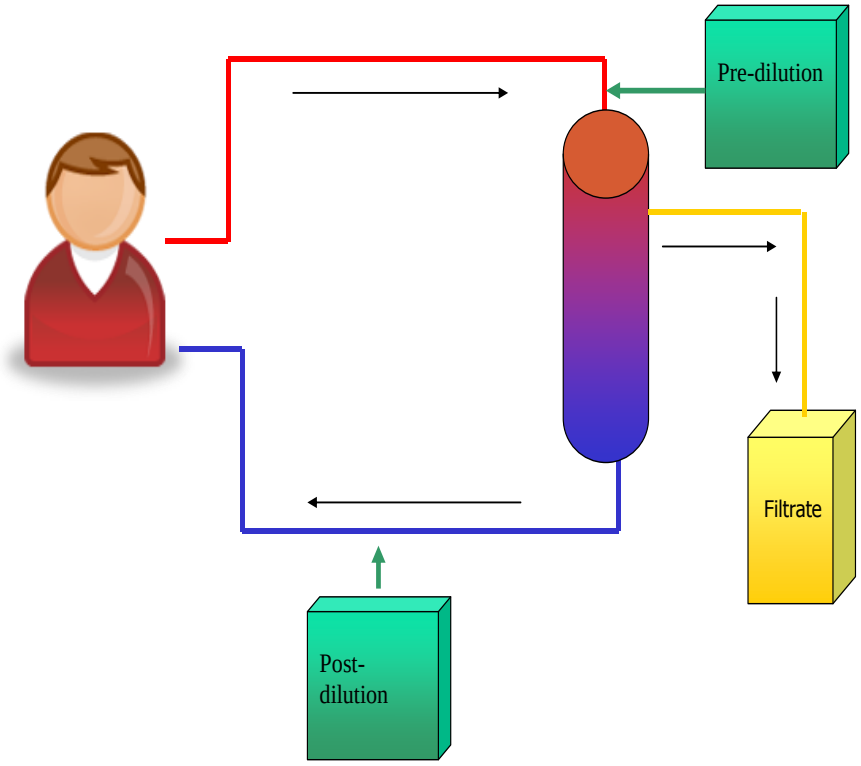
Fluid removal occurs by ultrafiltration exclusively. Excess plasma water is removed from the blood as it passes through the haemofilter. No replacement fluid is used. This mode is used for acute fluid overload conditions such as acute pulmonary oedema.



Continuous venovenous haemofiltration (CVVH)

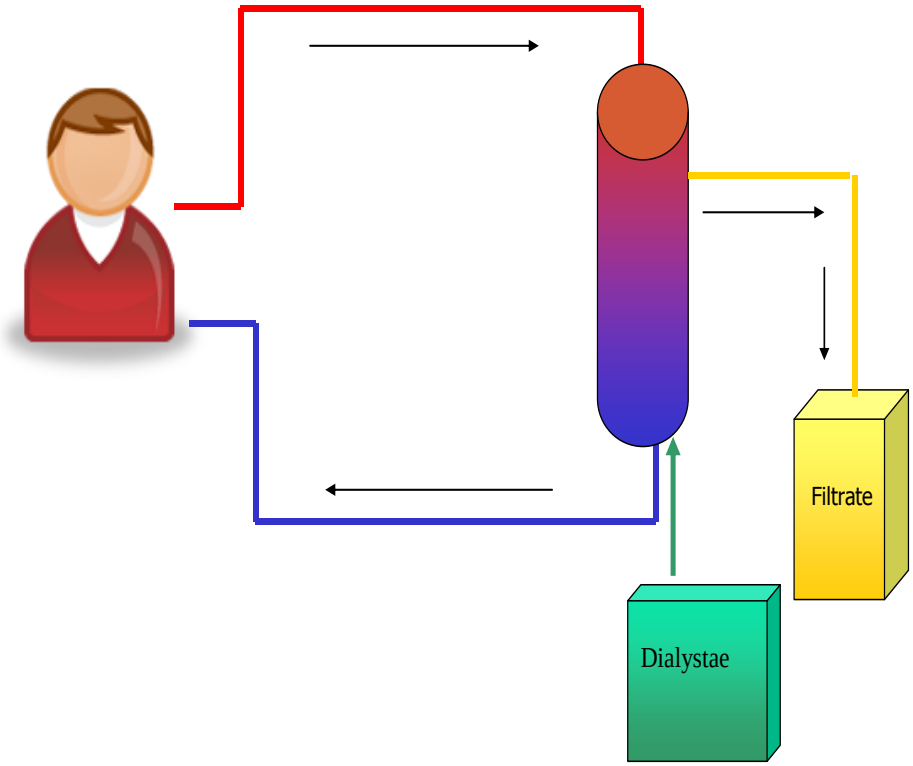
Solute removal occurs by using convection and patient fluid removal if desired. It offers high volume ultrafiltration using replacement fluid which can be administered pre-filter (pre-dilution) or post-filter (post-dilution).

Haemofiltration mimics glomerular filtration, water is forced through a semi permeable membrane by hydrostatic pressure, drawing solutes by convection.



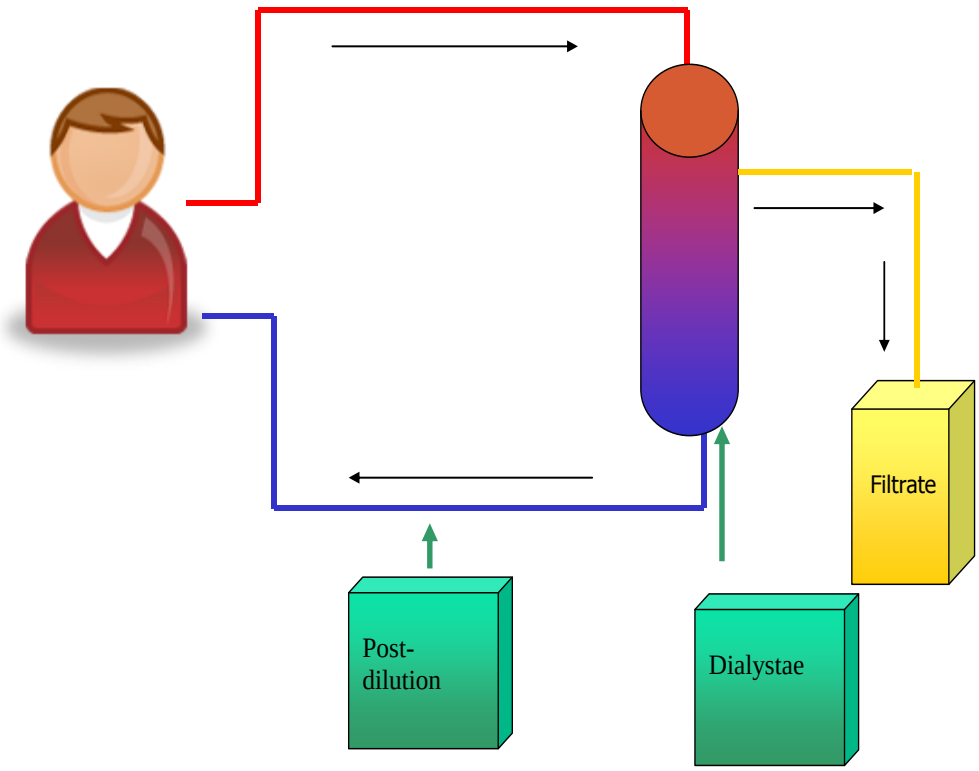
Continuous venovenous haemodialysis (CVVHD)

Solute removal occurs by diffusion and patient fluid removal if desired. Dialysate fluid enters the filter in a countercurrent direction to the blood flow. This enhances diffusion by maintaining a concentration gradient throughout the length of the filter. Only solutes that are small enough will pass through the membrane via diffusion.



Continuous venovenous haemodiafiltration (CVVHDF)

Haemodiafiltration combines haemofiltration and haemodialysis. Solute removal occurs by diffusion and convection simultaneously and fluid removal if desired. CVVHDF offers high volume ultrafiltration using replacement fluid which can be administered pre-filter or post-filter. Simultaneously dialysate is provided countercurrent to the blood flow.



Vascular access

A vascular access device (Vascath) will be inserted aseptically by medical staff. The vascath is a double lumen catheter. An additional side port may be present and can be used for medication and fluid administration. The sites for insertion are outlined below:

Internal jugular vein

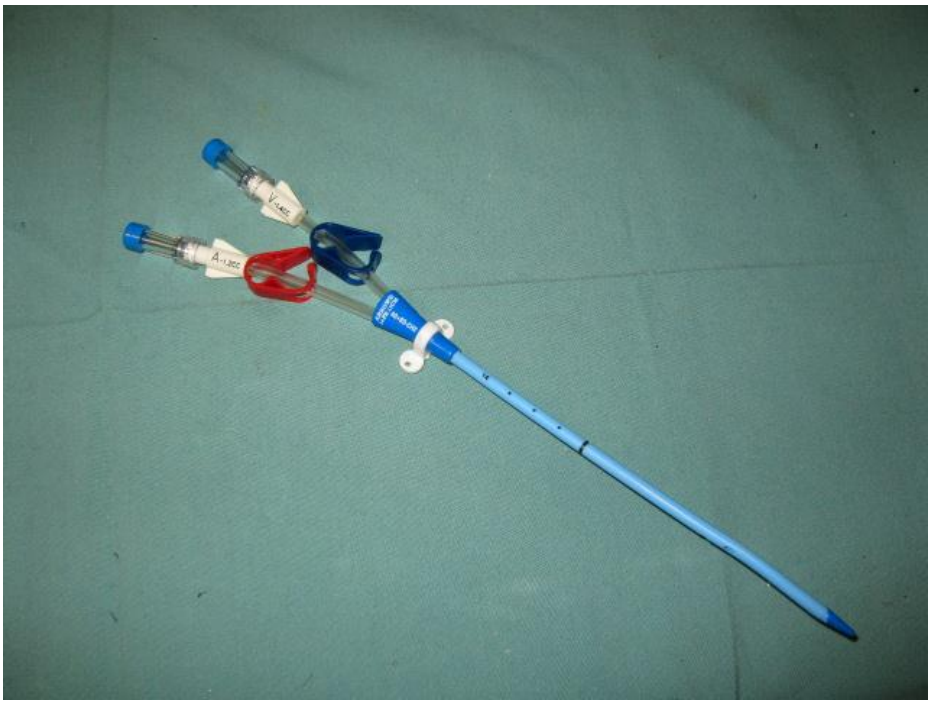
The right internal jugular vein is the preferred site for access. Interruptions to blood flow are less likely to occur when this site is selected as there is a natural tendency for the catheter to lie parallel to rather than against the vessel wall. Kinking may pose a problem if the patient is restless (Davies & Leslie 2006).

Femoral vein

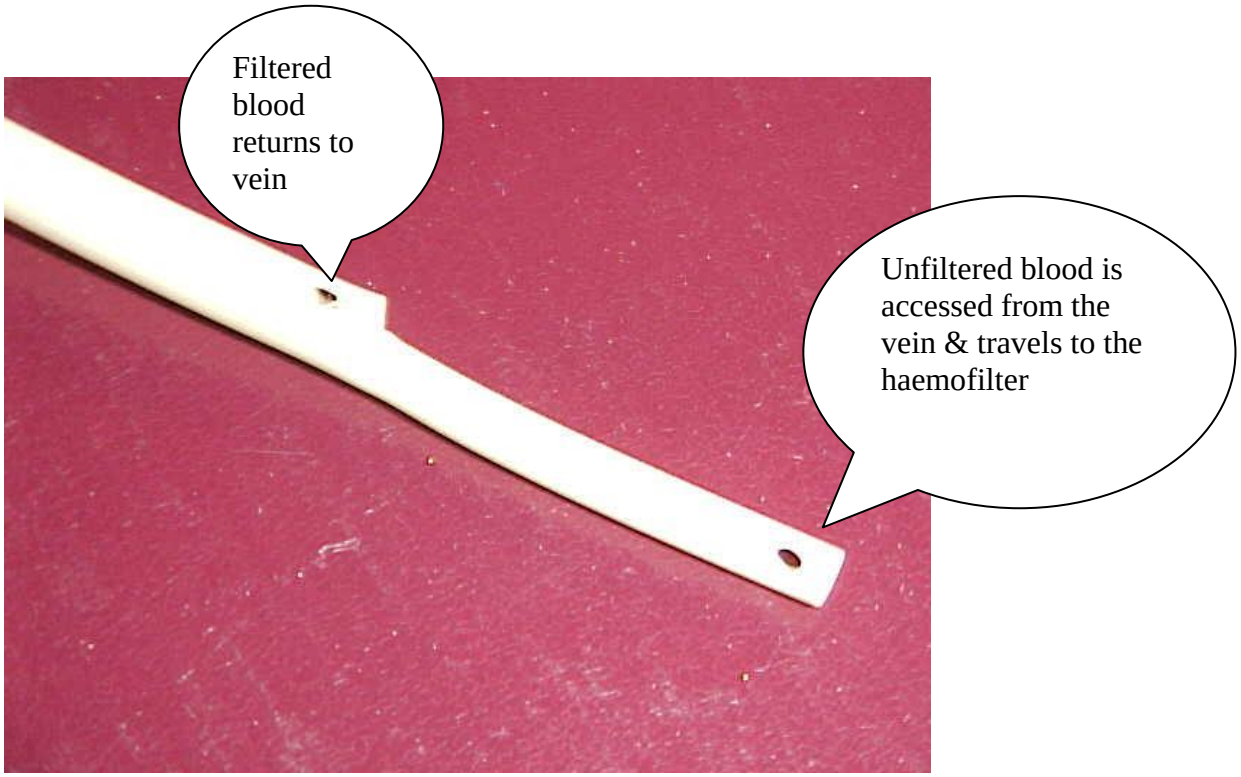
This site is selected when the internal jugular vein cannot be used. This site is also useful for the supine and sedated patient in intensive care. Access to a larger vessel at the femoral vein site will usually deliver improved blood flow, however kinking may pose a problem with hip flexion. When CRRT is required in an emergency situation, the femoral vein may be selected as it is often less complex to cannulate without delay. An arterial blood gas is required to ascertain the cannulated vessel is the vein.

Subclavian vein

This site is to be avoided. The catheter tip has a tendency to lie against the wall of the vessel or kink under the clavicle and result in inadequate blood flow, but most importantly venous stenosis may occur which can effect successful AV fistula formation for long term dialysis. Discussion with a Nephrologist must take place.



The vascular access device (vascath)



Lumens of the vascath

Potential complications of vascular access device

A common occurrence in critically ill patients with vascaths is flow associated problems. They are normally associated with low patient arterial blood pressure and high venous pressures (Baldwin & Leslie 2007). The performance of flow of any vascular access device is often related to the following

- Kinking of the catheter
- Catheter against the vessel wall
- Altered position of the vascath

Consider the following nursing interventions

- Reposition patient if kinking is suspected
- Ensure vascath is secure
- Check lines are not kinked (especially during pressure area care and patient movement)
- Rotate the vascath. This may assist if the catheter lumens are resting against a vessel wall
- Aspirate and flush the vascath to assess patency of the lumens
- Reverse lumens. Some minor recirculation may occur but this is minimal and of no concern

The haemofilter

The haemofilter can be referred to as the 'artificial kidney' and is the primary functional component of the CRRT system. It is responsible for separating plasma water from the blood and/or allowing the exchange of solutes across the membrane by diffusion (Baldwin & Leslie, 2007).

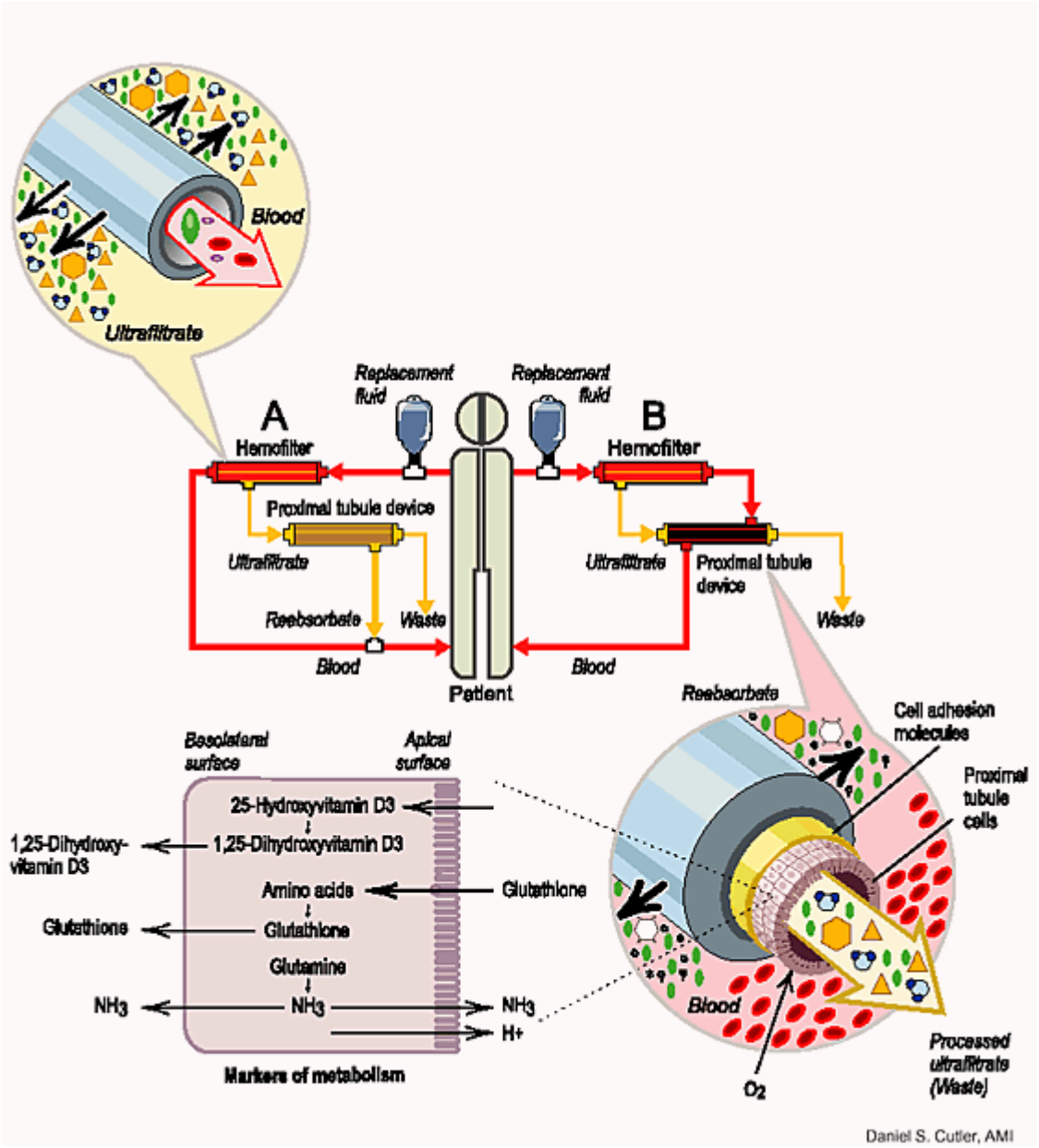
The filter is made of a plastic casing which contains a synthetic polymer inner structure arranged in longitudinal fibres. The fibres are hollow and have pores along their length. The fibres within the filter may vary in size and composition.

The filter pore size is measured in Daltons and allows small molecules to freely pass through the filter; however there is a restriction of the movement of medium sized

molecules and very little movement of large size molecules. Filter size is described in square meters. The larger the surface area in square meters, the greater the surface area for blood contact with the fibres resulting in the potential for increased ultrafiltration.

For the critically ill population the most important features of the filter include:

- a high plasma water clearance rate at low blood flow rates and circuit pressures
- high permeability to middle size molecular weight substances e.g. inflammatory cytokines



Circuit and filter life

The circuit and filter life depends on circuit mechanics and many patient factors including:

- mode of therapy
- utilisation of convective and/or diffusive processes
- method of fluid replacement
- patient anticoagulation status
- relative blood stasis and air – blood interface
- blood flow velocity

Potential complications of haemofiltration and Haemodiafiltration

- Blood loss – from venous access or other sites due to anticoagulation
- Clotting – of the filter/circuit
- Patient related – particularly if excess fluid removal increases haemoconcentration
    - Hypovolaemia
    - Electrolyte imbalance
    - Activation of inflammatory pathways (contact of blood with filter material)
    - Access site infection/sepsis
- Hypothermia – from exposure of blood to atmospheric temperatures or if temperature is not correctly regulated on machine
- Machine malfunction
- Blood leak from filter
- 'Disequilibrium' syndromes – generally related to haemodialysis and abrupt changes in urea levels

Now read the following chapter

Baldwin, I., & Leslie, G. (2012). Support of renal function. In Elliott, D., Aitken, L.,& Chaboyer, W. (Eds.), *ACCCN's Critical Care Nursing,* (2nd ed) pp 479-505 Sydney:Mosby,Elsevier

Please read the section titled 'Fluids and Fluid Balance', page 497-498

OR

Kellum, J., Bellomo, R., Ronco, C. (2009). *Continuous Renal Replacement Therapy* , Oxford University Press, USA

Please read Chapter 5: Principles of Fluid Management

After reading this section in the chapter complete the following.

Summarise the key nursing and medical responsibilities of fluid balance maintenance.

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Anti-coagulation

The need for anti-coagulation of the CRRT circuit is necessary because when blood comes in contact with the foreign surface of the tubing of the circuit and the membrane of the haemofilter the activation of the coagulation cascade is triggered. Both the intrinsic pathway of blood coagulation and the extrinsic pathway of platelet aggregation and adhesion to membrane material occurs. This extracorporeal activation of the coagulation cascade inevitably results in haemofilter or circuit clotting.

CRRT can be delivered without anti-coagulation, but the haemofilter will last much

longer if some form of anti-coagulation is used.
Excessive anti-coagulation may result in bleeding complications. The goal of anti-coagulation is to minimise the effects of membrane exposure and maintain the functional integrity of the haemofilter and patency of the circuit, whilst avoiding bleeding complications, therefore the anti-coagulation option that is best for each patient depends on the individual clinical scenario.

There are several anti-coagulants available to prolong the haemofilter or circuit life, however the two most frequently used with our intensive care include medium-dose pre-filter unfractionated heparin and citrate.

Heparin

This is the most commonly available anti-coagulant and works by inhibiting clot formation. It can be utilised in a number of different ways including:

- Low-dose pre-filter unfractionated heparin
- Medium-dose pre-filter unfractionated heparin
- Systemic unfractionated heparin
- Regional unfractionated heparin
- Low-molecularweight heparins
- Low-molecular weight heparinoids

Regardless of how heparin is administered it carries with it the risk of Heparin-induced thrombocytopenia and thrombosis (HITT). Therefore it is essential that platelet counts are monitored and HITT should be suspected if the platelet count decreases by 50% from the patient's baseline after heparin therapy has commenced. If HITT is suspected, all forms of heparin must be discontinued immediately.

Within our unit we utilise **medium-dose pre-filter unfractionated heparin** at a dose of 12 units/kg/hour. This dose reportedly mildly elevates the aPTT and can be used for patients with minimal risk of bleeding. The heparin may be administered using a pump integrated into the CRRT machine or via a separate pump. There are no controlled studies to confirm efficacy or safety (Bellomo, Baldwin, Ronco & Golper, 2002).

Citrate

Citrate is both an anti-coagulant and buffer. Regional anti-coagulation of the haemofilter can be achieved through the use of citrate. Citrate inhibits clotting in the circuit by chelating Calcium, a key cofactor in many steps of the clotting cascade. Its chelation decreases blood coagulability within the circuit. The blood that returns from the circuit mixes with the systematic circulation and the calcium concentration is restored to normal. Citrate is taken to the liver and metabolised to yield CO2/Bicarbonate and calcium is released back to the body. However, some calcium is lost in the ultrafiltrate and needs to be replaced by a separate infusion to maintain normal serum ionised calcium levels (normacalcaemia) (Bradford, 2005).

If citrate accumulates it can cause any combination of the following:

- Low ionised hypocalcaemia with a normal or elevated total calcium (normal total ionised calcium ratio = 1.9-2.1:1)
- Metabolic acidosis (decreasing Base Excess)
- Increasing anion gap

Now read the following journal article

Oudemans-van Straaten, H.M., Kellum, J.A., & Bellomo, R.(2011). Clinical Review: Anticoagulation for continuous renal replacement therapy-heparin or citrate? *Critical Care,* 15:202

This journal article can be assessed via the CIAP portal.

After reading this journal article complete the following:

Describe your understanding of the principles of action of citrate

_____

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State the potential complications of citrate accumulation

Workbook

1. State three types of acute renal failure

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2. What are the aims of treatment for the management of acute renal failure?

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3. List the indications for CRRT

_____

_____

_____

_____

_____

4. What is the composition of the substitution/replacement fluids used in ICU within the Intensive Care Services at John Hunter Hospital?

_____

_____

_____

_____

_____

5. Define diffusion

6. Define convection

7. Define ultrafiltration

8. Describe the fluid and solute movement behaviours utilised in haemofiltration and haemodiafiltration

9. Complete the following table:

Mode	Principles of Dialysis	Dialysate	Replacement fluids
SCUF	Ultrafiltration	No	No
CVVH			
CVVHD			
CVVHDF			

10. Outline the significance of and trouble shooting for the following alarms

High access/high return pressure alarm

_____

_____

_____

_____

Low access/low pressure alarms

_____

_____

_____

_____

Fluid balance alarms

_____

_____

_____

_____

Transmembrane pressure alarm

_____

_____

_____

_____

Blood leak alarm

_____

_____

Air detection alarm

Prefilter alarms

Low blood flow alarm

Heater cools down alarm

11. How is filter clotting detected?

12. State three interventions for the management of the hypothermic patient receiving CRRT

_____

_____

_____

_____

_____

13. Define the following terms in relation to achieving the fluid balance goal

Negative fluid balance

_____

_____

_____

Neutral fluid balance

_____

_____

_____

Positive fluid balance

_____

_____

_____

14. What is the recommended frequency of extracorporeal circuit change?

_____

_____

15. State what may affect the performance of flow through the vascath. Include the nursing and medical interventions which can be implemented to identify and eliminate them

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

16. When using citrate regional anti-coagulation why is a Magnesium Chloride infusion required?

_____

_____

_____

_____

_____

17. How often would you perform the following with **citrate** regional anti-coagulation?

Blood Values	**Frequency**
Arterial blood gas	
Electrolytes, Urea, Creatinine	
aPTT, PT	
Ionised calcium	
Total calcium	
Magnesium	

18. Describe the procedure of disconnection of the circuit on the Prismaflex machine

_____

_____

_____

_____

_____

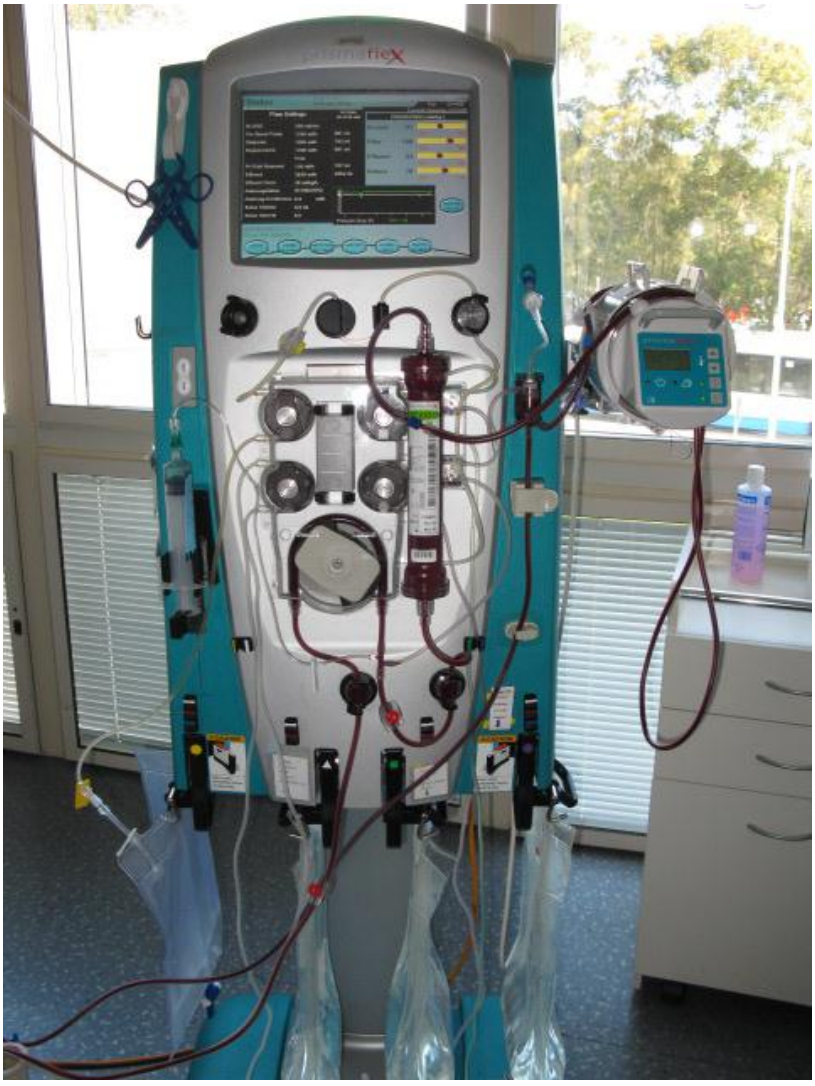
_____

_____

_____

19. The Prismaflex machine has been assembled for the delivery of CRRT. The mode of CVVHDF has been selected. Label the following on the diagram below

- Dialysate fluid
- Replacement fluid
- Access line
- Blood flow from patient to filter
- Blood flow from filter to patient
- Anticoagulation delivery device
- Return line
- Pre dilution line



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