PARTNERSHIP IN CRITICAL CARE DEPT. WAIKATO

CRITICAL CARE WAIKATO HOSPITAL

WORKBOOK

NAME: _____

Te Hanga Whaioranga Mô Te Iwi
Building Healthy Communities

Waikato District Health Board

Section three

Concepts of dialysis

Introduction

This section explores the life-maintaining therapy called ‘dialysis’. Those critical care patients who incur acute renal failure secondary to sepsis, multi-organ failure, acute injury or a disease process, may require the support of dialysis therapy, either in the short term or the longer term if a chronic picture emerges. This section discusses the three most common forms of renal replacement therapy: intermittent haemodialysis; continuous renal replacement therapy (CRRT) and peritoneal dialysis.

3.1 Physiology

All forms of dialysis use the principles of **osmosis** and **diffusion** to remove waste products and excess fluid from the blood. The dialysis filter provides a series of straw like tubules that are semi-permeable, through which blood flows. On the other side of the semi-permeable membrane dialysate flows in the opposite direction. Waste products such as creatinine and urea diffuse across this membrane from an area of high concentration (blood) to an area of lesser concentration (dialysate). H_2O on the other hand moves by osmosis to the solution that contains fewer H_2O molecules (Morton and Fontaine, 2013).

Haemodialysis and CRRT use extracorporeal (outside the body) circuits. Good vascular access is mandatory. An anticoagulation agent is usually added into the circuit to keep the blood from clotting.

3.2 Vascular access

Access for dialysis is achieved by one of 3 methods:

1. A vascular catheter
2. An arteriovenous fistula
3. A synthetic vascular graft

Methods 2 and 3 are used more commonly in chronic renal failure (see p638-9, Morton & Fontaine, 2013). In the ICU setting a vascular catheter ('Vascath') is the mode of choice.

Veins commonly used for Vascath placement are:

1. femoral
2. internal jugular
3. subclavian

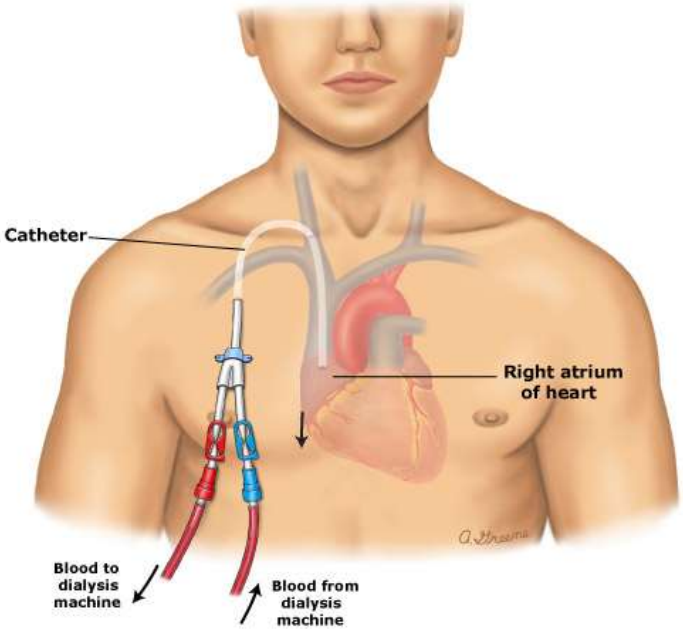

Fig 7. Vascath in internal jugular (Google images, 2013) author: Dr. Pradip Chakrabarti

The subclavian vessel is not preferred due to the higher risk of stenosis and occlusion complications.

The access lumen of the Vascath is a little longer than the return lumen. The blood is pulled from the vein into the access lumen, and then flows through the dialyser before re-entering the bloodstream via the return lumen. The return lumen is positioned slightly upstream from the access line, which minimises the recycling of freshly dialysed blood.

Nb. Conventionally, the access and return lines may be referred to as ‘arterial’ and ‘venous’, though in the veno-venous dialysis modes we use this is not technically correct, as they are both venous lines.

Refer to the **WDHB long term CVL management guideline** for further information on longer term vascular access for dialysis.

3.3 Anticoagulation:

Blood in the extracorporeal system, e.g. dialyzer and blood lines, is prone to clotting. A heparin infusion is commonly used to ensure the aPTT (activated partial thromboplastin time) is kept within a suitable range, usually 60-100 seconds.

Other citrate based solutions are utilised in intermittent haemodialysis with arguably fewer complications than heparin (Morton & Fontaine, p639) but these are not currently used in this ICU.

Usually, as well as coating the filter with a heparin-containing priming solution (5000units heparin in 1000mls N/saline in our Waikato ICU), a bolus dose of heparin is given before a smaller hourly rate is commenced. This results in **systemic** anticoagulation, where the patient’s clotting time is the same as the blood in the dialysis circuit.

Some units, in contrast use a **regional** anticoagulation treatment. This is where the patients clotting time is kept normal while blood is thinned as it passes through the dialyser. This is normally achieved using a heparin reversal agent such as protamine. It is not the common practise in our unit any longer, but it is worth being aware of. Intermittent haemodialysis can achieve this with trisodium citrate/calcium use as an alternative to heparin/protamine regimes. (see WDHB procedure: Prismaflex-anticoagulation)

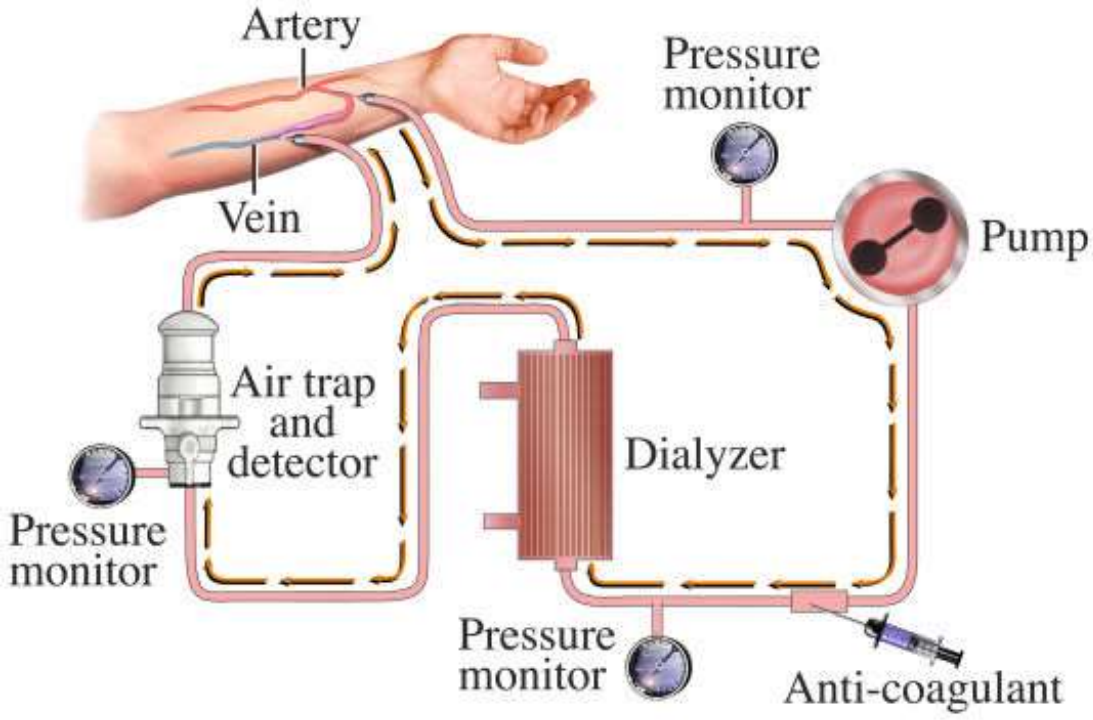

Fig 8. Haemodialysis via arterio-venous fistula (Smart image website, 2013).

3.4 Continuous Renal Replacement Therapies (CRRTs) and Dialysis Modes

CRRT (also referred to as slow continuous dialysis) is often used in the intensive care setting as it is more easily tolerated in the population group that is at high risk of haemodynamic instability. It involves a continuous therapy of up to 72 hours per treatment, which may be repeated to last from days to weeks depending on individual patient needs. It is therefore a slower, gentler treatment for AKI when compared to intermittent haemodialysis.

There are **four main modes of CRRT** that can be utilised with the veno-venous vascath access that we use in this ICU. Though we tend always to prefer CVVHDF (continuous veno-venous haemodiafiltration), it is important to understand all the modes so as to understand the benefits of CVVHDF more fully.

The possible modes are:

SCUF: Slow continuous ultrafiltration
CVVH: Continuous veno-venous haemofiltration (also written CVVHF)
CVVHD: Continuous veno-venous haemodialysis
CVVHDF : Continuous veno-venous haemodiafiltration

SLED (sustained low-efficiency dialysis) will also be discussed.

Slow continuous ultrafiltration (SCUF) - SCUF is generally used to remove excess fluid from fluid-overloaded patients who have developed a tolerance/resistance to diuretic drugs.

In SCUF therapy, a patient's blood is pumped through a haemofilter. Plasma water passes through the haemofilter membrane and is pumped into a waste bag. Unlike CVVHD or CVVHDF, no dialysate or fluid replacement therapy is used to help convey impurities from the blood through the filter and into the effluent. Figure 9. demonstrates a SCUF setup.

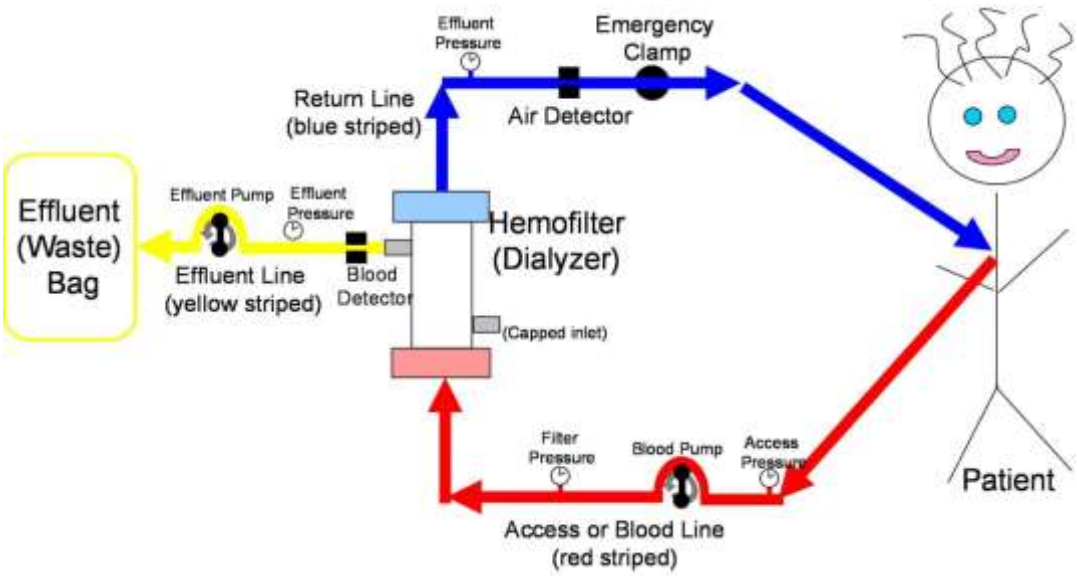

Fig 9. SCUF setup (Google images, 2013) Author not found.

In all these diagrams, the access line is labelled red, the return line blue, and the effluent line yellow, just as it is in the 'help' set-up menus on our dialysis machines.

Continuous veno-venous hemodialysis (CVVHD) - CVVHD is similar to standard dialysis that CRF patients get but is performed continuously over a longer period of time. The main principle of dialysis is diffusion. In dialysis, impurities and excessive electrolytes move from an area of high to low concentration. CVVHD is best at removing small molecules from the blood stream. Fig 10. demonstrates a CVVHD setup. You will notice the difference in that there is an added dialysis solution (green line).

This dialysate solution is usually a pre-mixed bag that is suspended underneath the Prismaflex (CRRT) machine. Unlike SCUF or CVVHF, CVVHD uses the dialysate to help convey impurities from the blood through the filter and into the effluent. It is effective in clearing small size molecules, such as creatinine and urea, and excess potassium. There is still no replacement fluid used in this mode.

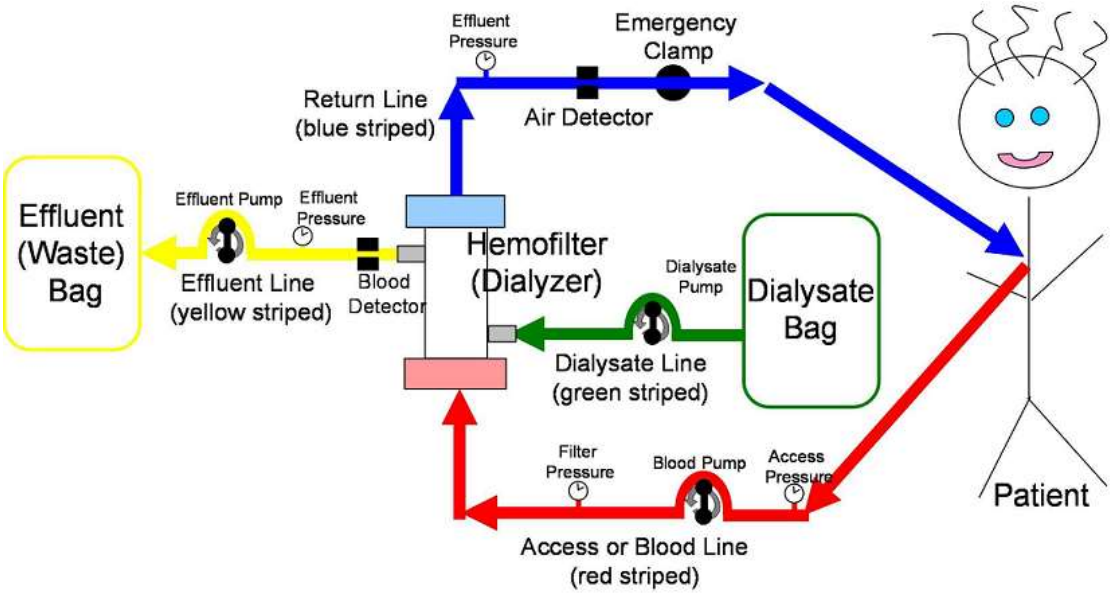

Fig 10. CVVHD setup (Google images, 2013)

Continuous veno-venous haemofiltration (CVVH)

In haemofiltration, solutes are moved across the dialyzer membrane through convection rather than by diffusion. With haemofiltration, or CVVH, dialysate is not used. Instead, a positive pressure drives water and solutes across the filter membrane from the blood compartment to the filtrate compartment of the dialyzer, from which it is removed through the effluent line and discarded. Solutes, both small and large, get passed through the membrane at a similar rate by the flow of water due to the pressure difference. Convection overcomes the reduced removal rate of larger solutes (due to their slower speed of diffusion) seen in haemodialysis.

Replacement fluid is added to the blood to replace fluid volume and electrolytes. The replacement fluid solutions in CRRT come in pre-mixed bags which are hung on the Prismaflex. The constituents of this fluid will be discussed in more detail later. Fig. 11 demonstrates this setup, with the replacement line coloured purple.

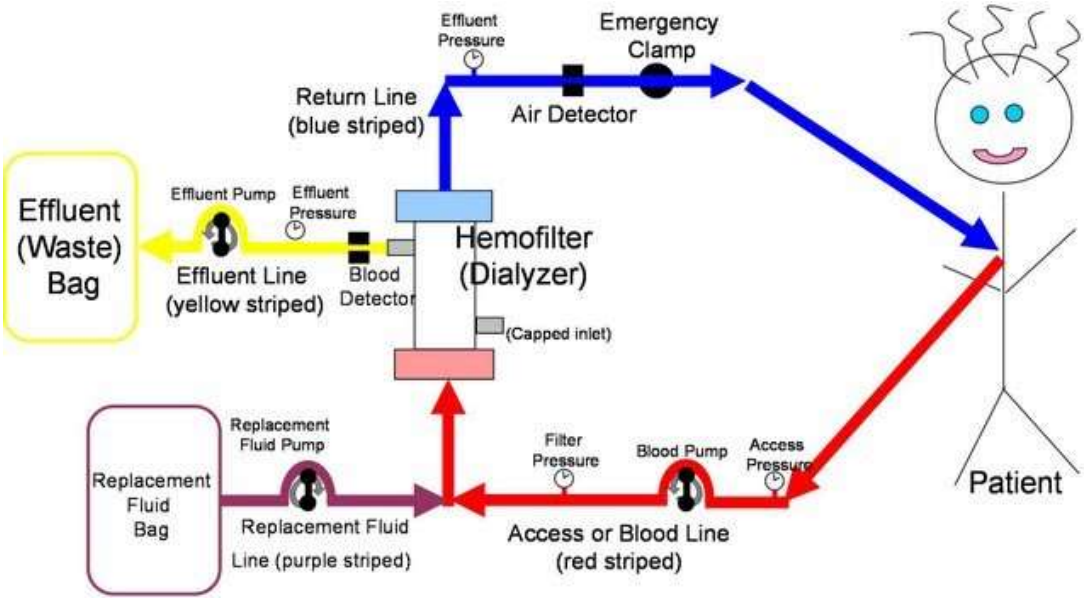

Fig.11 Typical CVVH set up (Google images, 2013). Author not found.

Continuous veno-venous hemodiafiltration (CVVHDF)

CVVHDF is probably the most common type of CRRT used. It combines aspects of both CVVHD and CVVH. In CVVHDF, dialysate and replacement fluid are both introduced into the circuit. Dialysate helps convey impurities from the blood through the filter into the effluent, whilst the addition of extra 'replacement' fluid into the circuit drives water and solutes across the filter membrane from the blood compartment to the filtrate compartment of the dialyzer (this is the 'convection', or 'solvent drag' mentioned earlier). The replacement fluid can be added to the blood pre or post filter. It replaces some of the fluids that are being removed from the blood and therefore helps balance the patient's blood fluid level. (Google, 2013). Fig .12 and 13. give picture representation. You can see from the picture by Gambro (Fig.12) that replacement fluid may be added either pre or post filter. When using the Prismaflex, these fluids are called PBD (pre-blood pump dilution) and PFR (post-filter replacement).

To summarise, **CVVHDF uses the principles of dialysis (essentially diffusion), PLUS convection**. This gives greater clearance of small and larger size molecules.

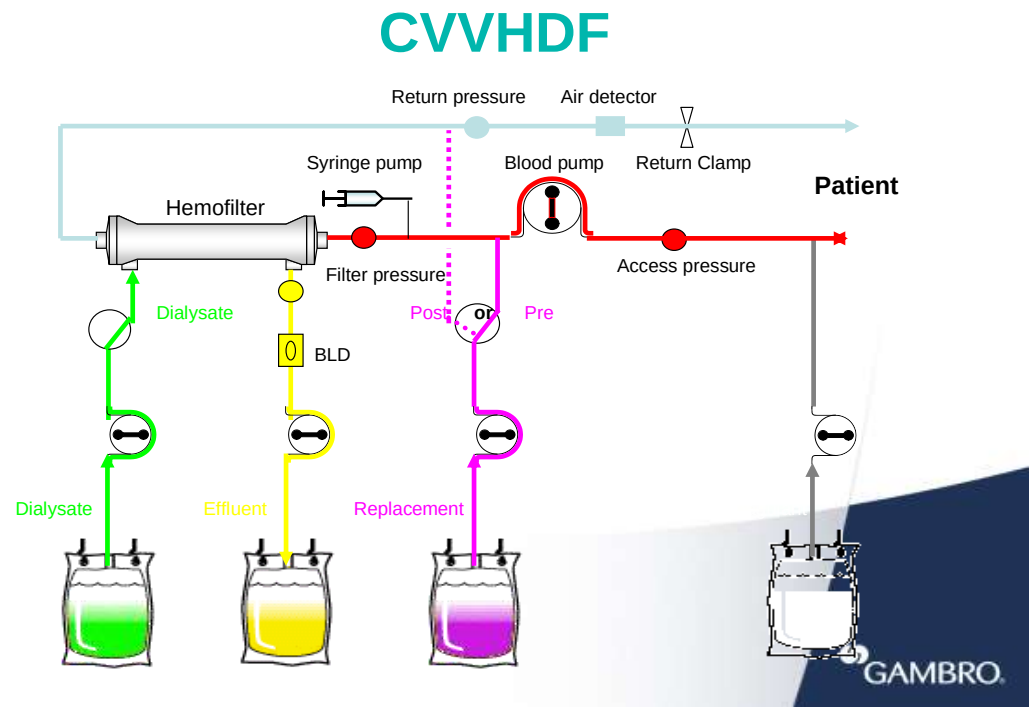

Fig. 12 CVVHDF set up (Gambro, 2012)

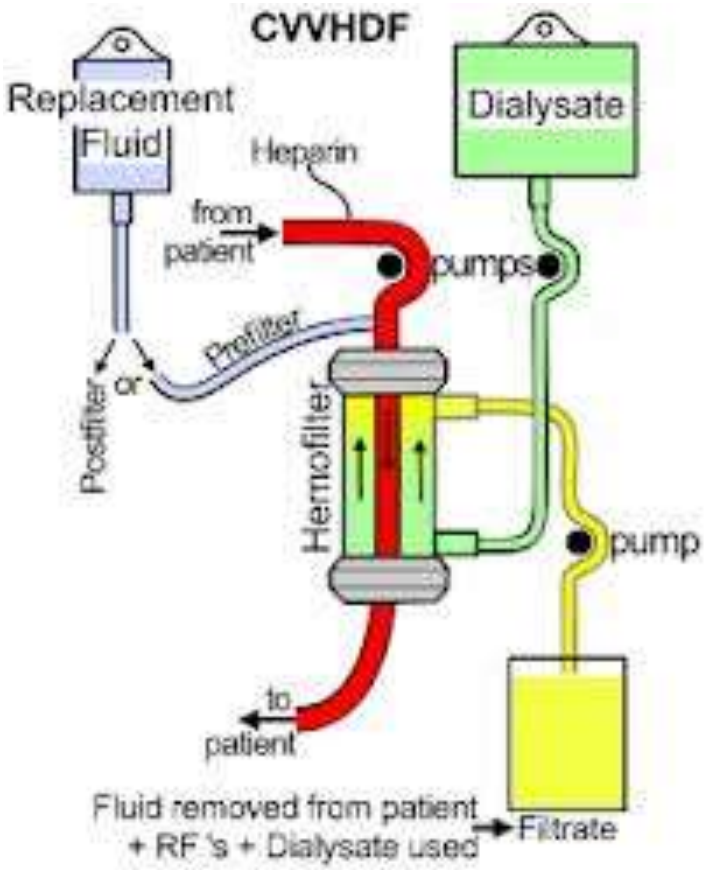

Fig 13. CVVHDF set-up with pre-filter replacement fluid (Google images, 2013). Author not found.

As mentioned, we utilise two types of dialysis machines in our critical care department. These are the Prismaflex and the Fresenius. The use of CVVHDF mode on the Fresenius machine is called SLED (sustained low efficiency extended dialysis) due to the differences in fluid flow rates and length of time of treatment. This is discussed below:

3.5 SLED (sustained low efficiency extended dialysis)

The basic concept of SLED as a form of dialysis is as follows:

- Fluid removal and solute clearance is slower than intermittent haemodialysis (IHD), but faster than CRRT. It can be performed over an 8-10 hour period but we usually administer it for 4- 6 hours. It is conducted on a daily basis in the critical care department based on the patient's continuing needs.
- The dialysate and replacement fluids used are made up by the machine, combining ultra-purified tap water (purified by passing through carbon and chlorine filters, and then tested before use) along with acid and base components to make up a dialysate solution similar to the bags used with Prismaflex in constitution. However, much larger quantities of fluid exchanges occur with SLED, resulting in much more efficient dialysis. In particular, there is more efficient convective clearance of larger sized molecules (e.g. such as many of the inflammatory mediators involved in sepsis).

(Gambro, 2004)

The form of SLED that we use in this unit can more accurately be termed as ***Extended daily diafiltration (EDD-f)*** (Fresenius Medical website, 2013)

Some other **advantages** of this therapy are as follows:

- Potentially reduced need for coagulation due to increased convective flow and pre-filter dilution
- Advantages of improved patient mobility secondary to reduced dialysis connection time
- Potential for night therapy leaving day free for other procedures
- Cost saving due to use of ultrapurified tap water use for dialysate and replacement fluid
- Potential greater clearance of larger sized molecules secondary to increased convective flow
- There is better uraemic, electrolyte and pH control than with IHD.

Some **disadvantages** of SLED/EDD-f may be:

- Cardiovascular instability (including hypotensive episodes) is possible due to more rapid fluid and electrolyte shifts.
- A disadvantage over CRRT is increased risk of exposure to pyrogens, bacteria, and water contaminants due to the use of tap water instead of sterile bags of pre-made dialysate fluid

Water purification: The Aquano reverse osmosis unit pictured below is used to treat ordinary tap water and purify it for use in dialysis. It contains carbon and chlorine filters that remove contaminants and electrolytes, resulting in ultrapurified water entering the Fresenius machine. The water is tested for purity and chlorine presence before use. The water quality is tested monthly by the technicians in our ICU for presence of contaminants, It is then mixed in the dialysis machine with acid and base components to make dialysate and replacement fluid. It is further tested for presence of chlorine by the nurse during setup before each use.

Fig. 14: The aquano reverse osmosis unit (Fresenius Medical, 2013)

The process of water purification is known as **reverse osmosis.** The ultra pure water that exits the reverse osmosis unit is called **permeate.** It passes through two more filters in the machine itself to reach an ultimate standard of purification.

Once the processed water or permeate reaches the dialysis machine it is mixed with the 2 components of dialysate 1) Part A – Electrolyte Concentrate
2) Part B – biBag 900gm sterile bicarbonate powder
The dilution ratio is 1:34 or 35 Fold
i.e – 1 part of Concentrate (Part A)
+ 1.225 parts of Bicarbonate (Part B)
+ 32.775 parts of water
This is the dialysate dilution ratio and may not be changed
(Fresenius, 2008).

How Is Ultra Pure Dialysate Produced?

Ultra-pure dialysate is produced by ensuring that stringent water testing guidelines are adhered to. The use of powdered bicarbonate and the use of a new concentrate bottle minimizes the introduction of microorganisms to the water. After passing through the 1st DIASAFE*plus* filter (in the machine itself) the fluid is classed as ultra pure, after passing through the 2nd DIASAFE*plus*

filter- Fluid is equal to the European Pharmacopoeic standards of sterile solution. (Fresenius, 2008).

3.6 Transport mechanisms in dialysis

Ultrafiltration: The movement of fluid through a semi-permeable membrane driven by a pressure gradient – (produced by positive pressure on the blood side of the membrane and negative pressure on the fluid side of the membrane).

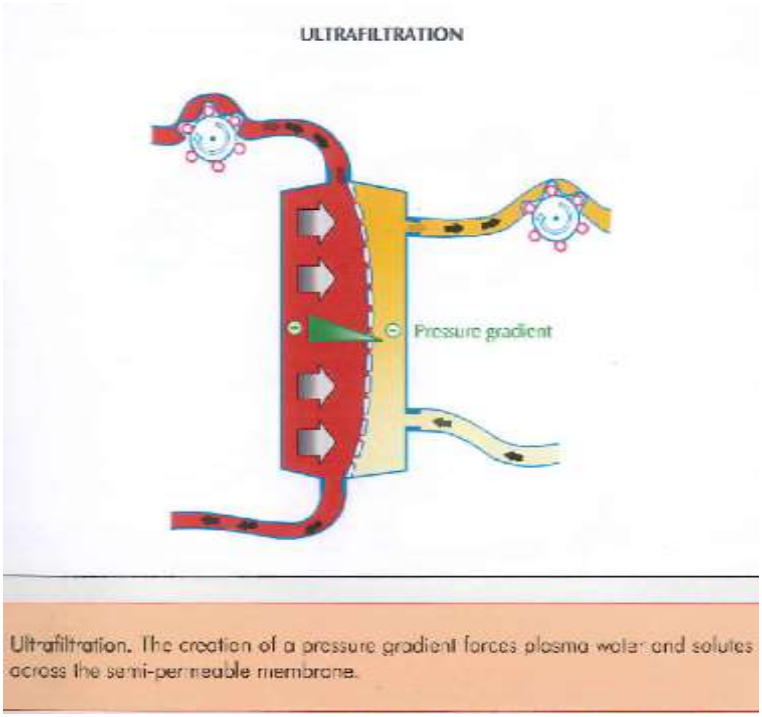

Fig.15. (**Gambro, 2004)**

Convection: The movement of solutes with fluids (also known as as 'solvent drag').

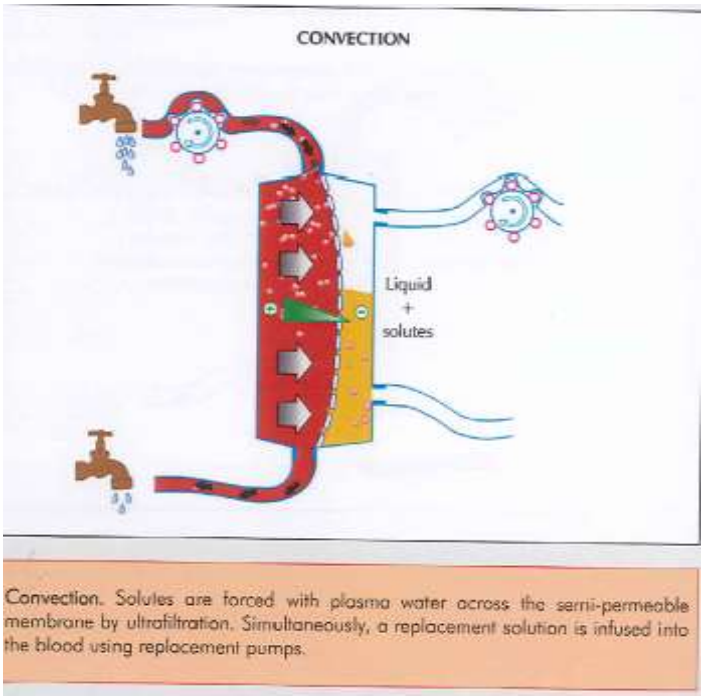

Fig. 16. (Gambro, 2004)

Diffusion: The movement of solutes from a higher concentration to a lower concentration across a semi-permeable membrane.

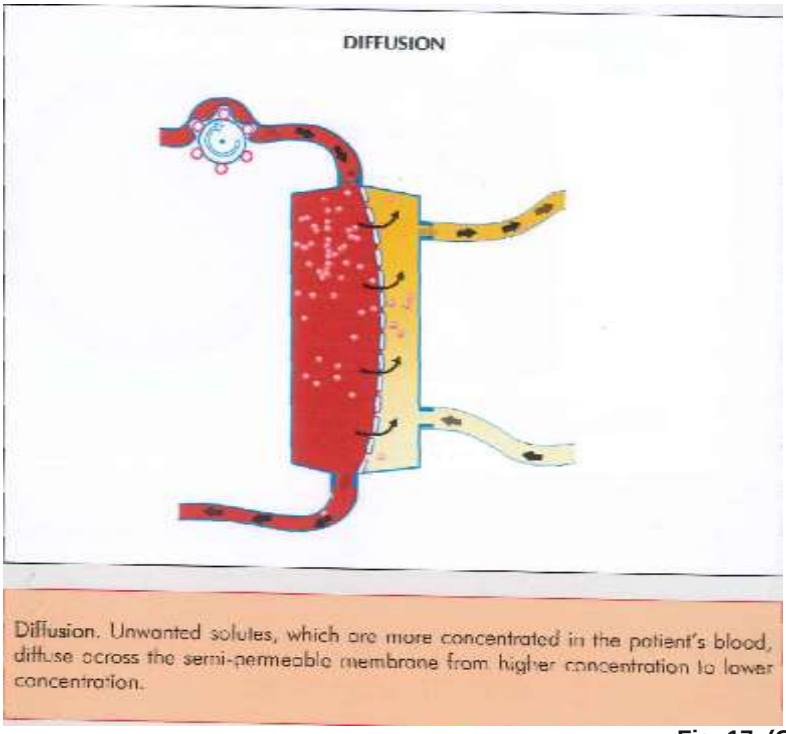

Fig. 17. (Gambro, 2004).

Adsorption: The clearance of molecules by adherance to the surface of interior of the semi-permeable membrane.

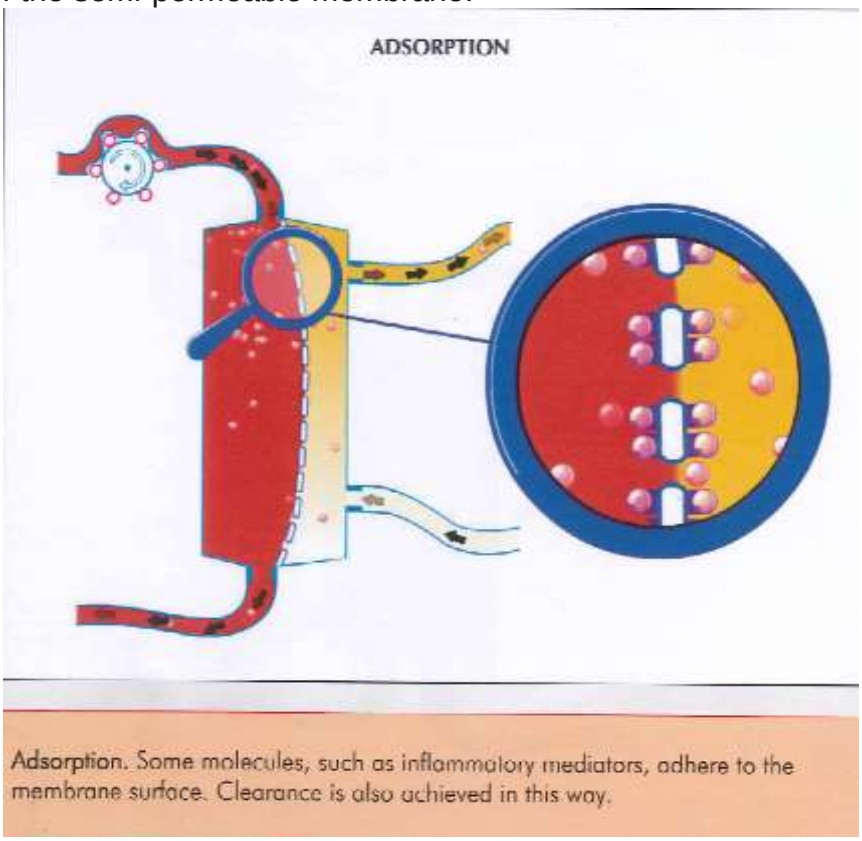

Fig. 18. (Gambro, 2004).

3.7 The Filter:

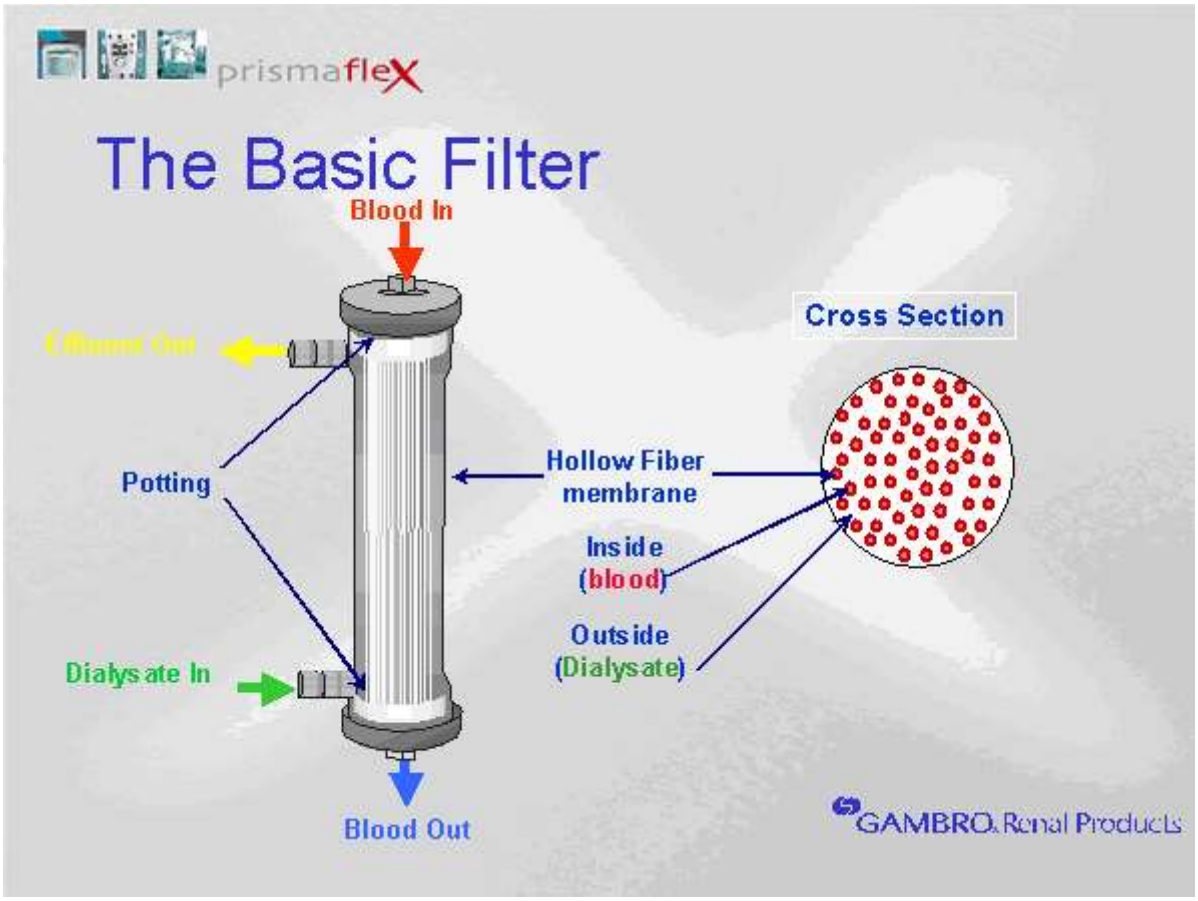

Fig. 19. The filter function (Gambro, 2013)

Filter permeability is influenced by pore size, the number of pores and the thickness of the membrane. Filters can be referred to as high or low flux. Generally, the high flux membranes have more or larger pores allow more solutes and ultrafitrate to move across the membrane. Thinner membranes offer less resistance to solute movement by decreasing the distance the solute must travel across the membrane and also favour increased filtration.

Solutes are passed through the membrane according to solute size, much like a sieve. Dialysis membranes act the same way, allowing small and mid sized molecules to pass across the membrane, without the loss of larger proteins. High flux membranes with a larger pore sizes increase clearance by allowing larger molecules to pass through the membrane, and by allowing more ultrafiltrate flow. The standard AN69 filter used in the prismaflex system is a high flux membrane (London health Sciences, 2013).

3.8 Indications for dialysis

There are diverse reasons a patient in the critical care setting may require dialysis, including;

- Anuria secondary to acute renal failure
- Symptomatic pulmonary oedema unresponsive to diuretics
- Severe electrolyte disturbances
- Metabolic acidosis

- Uraemic complications involving other organs (e.g. Pericarditis, encephalopathy)
- Drug/toxin overdoses that are dialyzable
- Treatment of sepsis - clearance of septic mediators

(Morton & Fontaine, 2013)

3.9 Continuous Ambulatory Renal Dialysis (CAPD)

Peritoneal dialysis is another form of dialysis used for patients with chronic renal failure. It uses the peritoneum as the semi-permeable membrane and osmosis is used to remove fluid, and diffusion of waste solutes, rather than pressure differences.

A Tenchoff catheter is inserted surgically to gain access to the peritoneal cavity, and patients or family members are given training to perform bag exchanges using asceptic technique, but in the critical care area this would normally be performed by nursing staff.

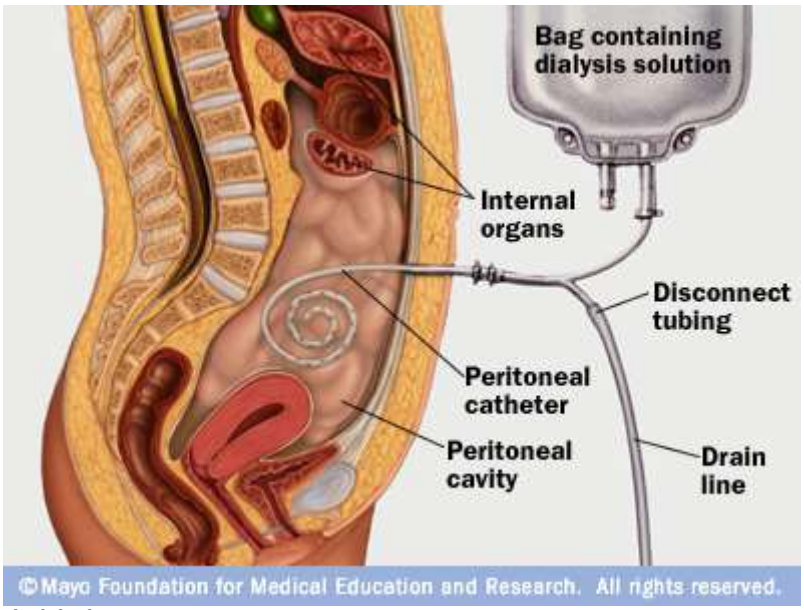

Fig.20 Peritoneal Dialysis

Indications for use:

- Haemodialysis is unavailable
- Vascular access is not possible
- Accomodating lifestyle choices. E.g., ability to maintain a job, ability to manage own dialysis

Disadvantages:

- More time needed to remove waste products adequately (dwell time is usually 4-6hrs minimum)
- Risk of peritonitis
- Complications from long periods of immobility.

This topic will not be covered in depth in this manual. For further reading refer to Morton & Fontaine, pp650-652. There are also WDHB procedures in the reference list and a training book for home training available from the Renal Ward.

Required reading

Morton, P and Fontaine, D. (2013). *Critical care nursing: a holistic approach*. 10th ed. Lippincott, Williams & Wilkins: Philadelphia. Read pages 637-

Additional reading

Gambro (2004): Renal Intensive care Self Directed Module. Version 1, Gambro Lundia AB.

London Health Sciences Website (2007). Updated July 02, 2013, http://www.lhsc.on.ca/Health_Professionals/CCTC/elearning/crrt/crrt.htm

References

https://sites.google.com/site/crrtinfo/ retrieved on 21 August 2013

Fresenius medical website. 2013. Retrieved Sept 13, 2013 at http://fmc-au.com/therapy-systems-and-services/acute-dialysis/acute-dialysis-products

http://kidney-dialysis.net/peritoneal-dialysis/peritoneal-dialysis-catheter-placement/Rationale for use:

London Health Sciences Website (2007). Updated July 02, 2013, http://www.lhsc.on.ca/Health_Professionals/CCTC/elearning/crrt/crrt.htm. Retrieved on 17 September, 2013

WDHB procedure 1095: (June 2012) Prismaflex - anticoagulation

WDHB protocol 3187: Continuous Ambulatory Peritoneal Dialysis (CAPD) Bag Change

WDHB procedure 2479: CAPD Catheter (continuous ambulatory peritoneal dialysis) insertion, care following

Acknowledgements

Fresenius, ARrT plus Training Guide. 2008. Electronic copy

Section five:

Dialysis management and complications

5.1 Priming the Prismaflex and patient connection

Regarding setting up the machine, maintenance and trouble shooting, much of this information will be included in practical form and in competency assessment in the workbook attached to this module. However, there are a few points to be discussed in this handbook:

Prismaflex: – no protocol exists as the on-line help menu on the machine is considered sufficiently user friendly. However, a competency performance skill checklist is required to be signed off as 'achieved' in the attached workbook to this module and serves as a useful reference

For information on set up of the Fresenius 5008 please access the unit protocol titled:

Ref 1323: Fresenius 5008 dialysis machine

5.2 Anticoagulation therapy

Usually, anticoagulation with heparin is used to minimise the risk of clotting the filter or of the patient receiving clotted blood post filter. Although heparin is the preferred anticoagulant in our ICU, other options are available such as the use of citrate solutions. It is possible to utilise citrate solutions or run heparin-free dialysis when the patient has a history of reaction to heparin.

Nb. Haemolytic heparin-induced thrombocytopoenia (HIT) is the development of thrombocytopoenia (a low platelet count), due to the administration of various forms of heparin. HIT predisposes to thrombosis, the abnormal formation of blood clots inside a blood vessel (Wikepedia, 2013). Patients with a history of HIT will normally receive therapy with no anticoagulant but may **receive** trisodium citrate as an alternative.

For patients without HIT and who have normal coagulation, heparin is normally added to the Prismaflex priming bag in order to apply a heparin coating on the filter before dialysis. In most cases, a bolus dose is also prescribed, to be administered at commencement of treatment. Then heparin is infused continuously according to the prescription and titrated to an APTT target (60-100 seconds, commonly).

5.3 Monitoring/Documentation

Pressure measurements are recorded on the 24 hr chart, in addition to the total hourly fluid removal (in the fluid balance section). Normally recorded are:

Access pressures (normal = -50 to -150mmHg)
Return pressures (normal = +50 to +150mmHg)
Filter pressures (normal = +100 to +250mmHg)
(Normal pressures documented are representative of the Prismaflex circuit).
TMP pressure (Fresenius only) (normal range = 0 to +300mm Hg)

Reasons for **abnormal pressures are discussed in the complications section** below:

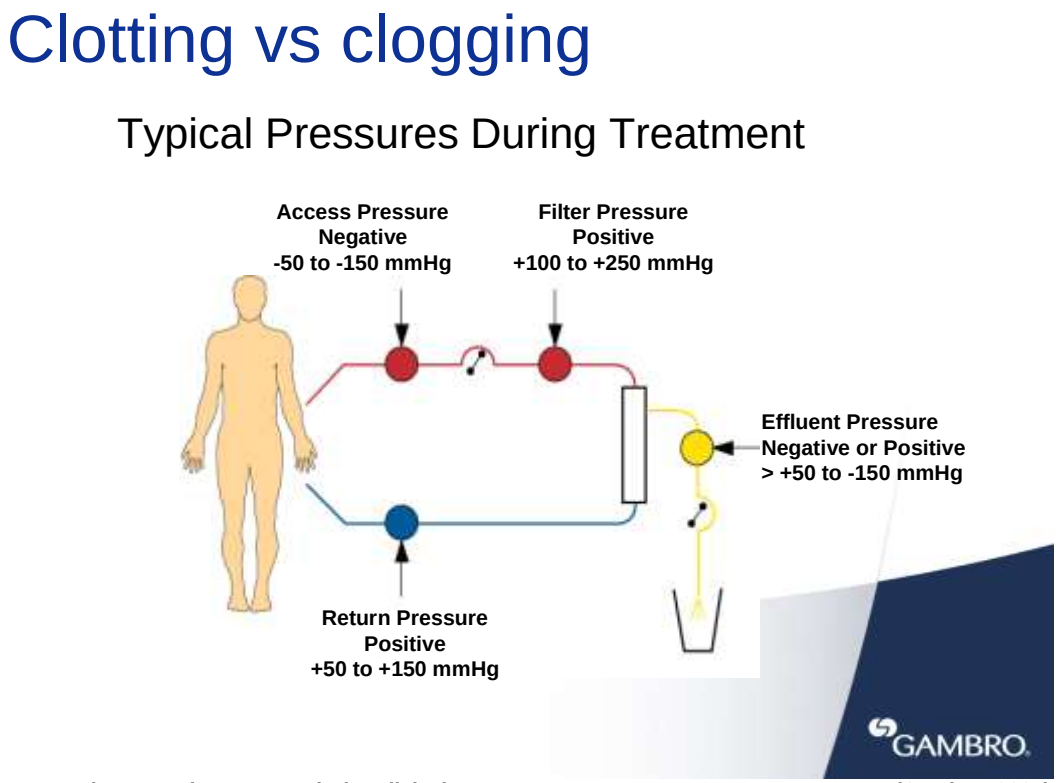

Fig.21. Normal expected pressures during dialysis treatment. **(Gambro, 2004)**

5.4 Complications with CRRT:

Dialysis disequilibrium

Uraemia must be corrected slowly to prevent disequilibrium syndrome. This involves a set of symptoms ranging from headache, nausea, restlessness, mild mental impairment to vomiting, confusion, agitation and seizures. It is the result of fluid shift of water from plasma to brain cells causing cerebral oedema. Blood urea and nitrogen levels play a key role (Morton & Fontaine, 2013).

Hypovolaemia

Hypovolaemia may result as a consequence of too rapid a removal of fluid. In order to maintain an adequate intravascular volume, fluid must shift from extravascular spaces of other body compartments to replace fluid removed during dialysis. Removing fluid too quickly may result in inadequate intravascular volume (Morton & Fontaine, 2013).

Hypotension

A balance must be obtained between fluid removal and movement of fluid into intravascular space as mentioned above. Some dialysis modes such as the Fresenius SLED therapy can help control problems with hypovolaemia and hypotension by altering the level of sodium in the dialysate and replacement fluid, assisting with osmotic gradients. Caution as to the effects of sedation and antihypertensives on worsening hypotension should be considered for the population group in the ICU setting (Morton & Fontaine, 2013).

Although we utilise a dual lumen catheters in all our dialysis modes, careful attention should be paid to effects on blood pressure at the commencement of dialysis, observing for hypotension.

If prescribed, small boluses of 100-200mls of normal saline may correct temporary problems of hypotension.

Muscle cramps

Muscle cramps may occur as a result of excess fluid removal, and consequent reduced muscle perfusion. Administration of hypertonic solutions can be utilised to correct this problem, though in our ICU population it is rarely reported as we are conservative with fluid removal and patients often have reduced conscious levels (Morton & Fontaine, 2013).

Dysrhythmias

Dysrythmias are not commonly seen but may occur in patients with underlying cardiac disease in response to fluid and electrolyte removal. Medical assistance should be sought to treat dysrhythmias.

5.5 Technical complications

Access problems:

Blood flow volumes in CRRT are now not much lower than in conventional dialysis. We are generally aiming for 250-300mls though this is not always achievable on the Prismaflex. Poor access will jeapordize successful dialysis. Position of the catheter may influence access flow. An obstruction from a clot or a kink in the catheter lumen or the line will cause abnormally high access pressures (e.g. a bent leg in a femoral catheter placement).

In the chart below are the upper and lower pressure limits preset in the Prismaflex. Bear in mind, clotting can occur long before these pressure limits are reached.

Extreme pressure limits

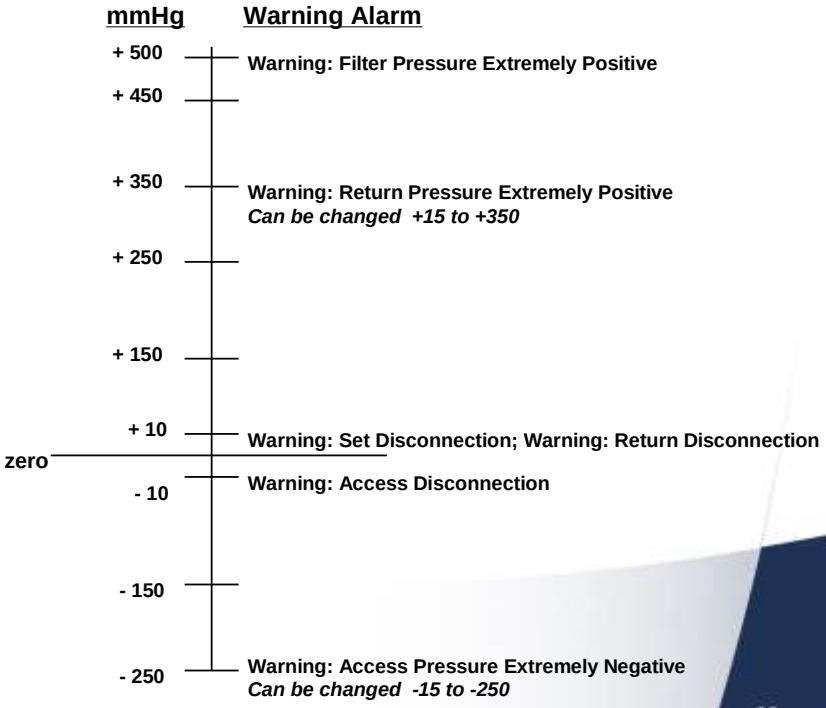

Fig.22. Extreme pressure limits

(Gambro, 2004)

Clotting

Trends in pressure changes are important to monitor as they will give clues as to the likelihood of the circuit clotting. As clotting progresses, return pressure will rise and access pressure drops. The blood lines and blood in filter will appear darker, and clots may be visible. Reduced ultrafiltration rate may also give an early sign of potential clotting (Morton & Fontaine, 2013).

A bolus of normal saline may help determine the nature and extent of a clotting problem and extend the life of the circuit temporarily. If clotting continues to progress, the patient's blood should be returned to them before clotting reaches a late stage, otherwise the patient will lose this significant volume of blood if the circuit clots completely. Clots returning to the patient are a significant risk, as embolus could lodge in the thorax, or heart causing ischaemia. However, these are normally trapped by the filters in the circuit.

Air in circuit

The dialysis circuit should be free of air after priming and during patient treatment. Air could potentially enter from a pre-filter infusion line running dry or via loose connections. Air in the circuit will collect in the drip chamber and

set off the air detector alarm, which triggers automatic clamping of the venous line by the dialysis machine.

The nurse should assess the circuit for the source of air, and ensure all bubbles have been tapped out of the drip chamber, and all connections are secure before resetting the line clamp. ***Ensure there is no danger of air returning to the patient*** (Morton & Fontaine, 2013).

Blood leaks

If there is any rupture inside the filter, blood will appear in the ultrafiltrate. The blood leak alarm sounds and the blood pump will stop. Blood can be safely returned to the patient unless there is gross blood in the ultrafiltrate, which will be clearly visible. The circuit should then be changed (Morton & Fontaine, 2013).

Hypothermia

The risk of hypothermia is minimised by the use of a blood warmer circuit in the Prismaflex. The Fresenius 5008 machine has its own internal warmer and temperature setting is routinely checked when therapy is programmed pre-treatment.

Required reading

Morton, P. & Fontaine, D. (2013). *Critical care nursing: a holistic approach*. 10th ed. Lippincott, Williams & Wilkins: Philadelphia. Read pages 637-

Additional reading

Gambro (2004). Renal Intensive Care Self Directed Module. Version 1. Continuous renal replacement therapy. Gambro Lundia AB.

References

WDHB procedure. Intensive Care specific. (2011).Ref 1323: Fresenius 5008 dialysis machine

WDHB Module 5. Renal workbook (2013)

Section six:

Miscellaneous extras

6.1 Drugs affecting renal function

There are many commonly used drugs that affect renal function, some of which are very nephrotoxic if not maintained within in therapeutic range.

Commonly-used drugs affecting renal function
• Diuretics • Beta blockers • Vasodilators • Non-steroidal anti-inflammatory drugs • ACE inhibitors • Aminoglycosides • Radio contrast media • Compound analgesics • Antiviral agents • Lithium

(Saker, B. 2000)

As it is the kidney's function to filter blood and excrete wastes, including potentially toxic drugs, the vasculature, tubules and tissue components of the kidney are exposed to high concentrations of substances. This can cause adverse effects.
This section covers only a brief introduction to the subject, as it considers some of the more common medications affecting renal function.

Pre-renal factors

Drugs that affect circulating blood volume, effective cardiac pumping, and peripheral resistance may cause kidney damage.
These may include;

Diuretics, particularly potent loop diuretics such as *furosemide*, which may cause volume depletion. Furosemide will be discussed in more detail later in this module. ***Drugs with negative inotropic effects*** such as ***beta blockers*** and some ***calcium channel antagonists*** have the potential to impair renal function, especially if cardiac output is already compromised (Saker, B. 2000).

Vasodilator drugs rarely cause deterioration of renal function themselves. However, they may be associated with marked salt and water retention, requiring the addition of loop diuretics (Saker, 2000).

Non-steroidal anti-inflammatory drugs (NSAIDs)

NSAIDs inhibit prostaglandin synthesis, leading to unopposed, intrarenal vasoconstriction. This decreases the glomerular filtration rate (GFR). It can

lead to fluid retention, with increasing risk of cardiac failure in pre-existing cardiac dysfunction. It may also lead to resistance to antihypertensive therapy in patients with normal cardiac function. Rarely, NSAIDs may cause acute interstitial nephritis, resulting in acute renal failure requiring dialysis (Saker, 2000).

Angiotensin converting enzyme (ACE) inhibitors

ACE inhibitors interfere with the production of angiotensin II. The result is a decrease in efferent arteriolar regulation. Significant alterations in renal function may result, especially in low perfusion states. Effects can be adverse or mild. A small deterioration in renal function may occur in patients who have no reno-vascular disease, but have a pre-existing mild elevation of serum creatinine. Discontinuing the ACE inhibitor may reverse this effect in most cases (Saker, 2000).
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Parenchymal damage

Many drugs can cause structural damage to the renal parenchyma. This usually presents as **acute tubular necrosis.**

Aminoglycosides antibiotics (eg's. gentamicin, tobramycin, amikacin) remain a relatively common cause of acute deterioration in renal function, having the potential to cause significant morbidity. Clinically, the onset of renal failure may be quite insidious because oliguria is not usually present. A warning sign may be the development of hypokalaemia which precedes the rise in creatinine (Saker, 2000).

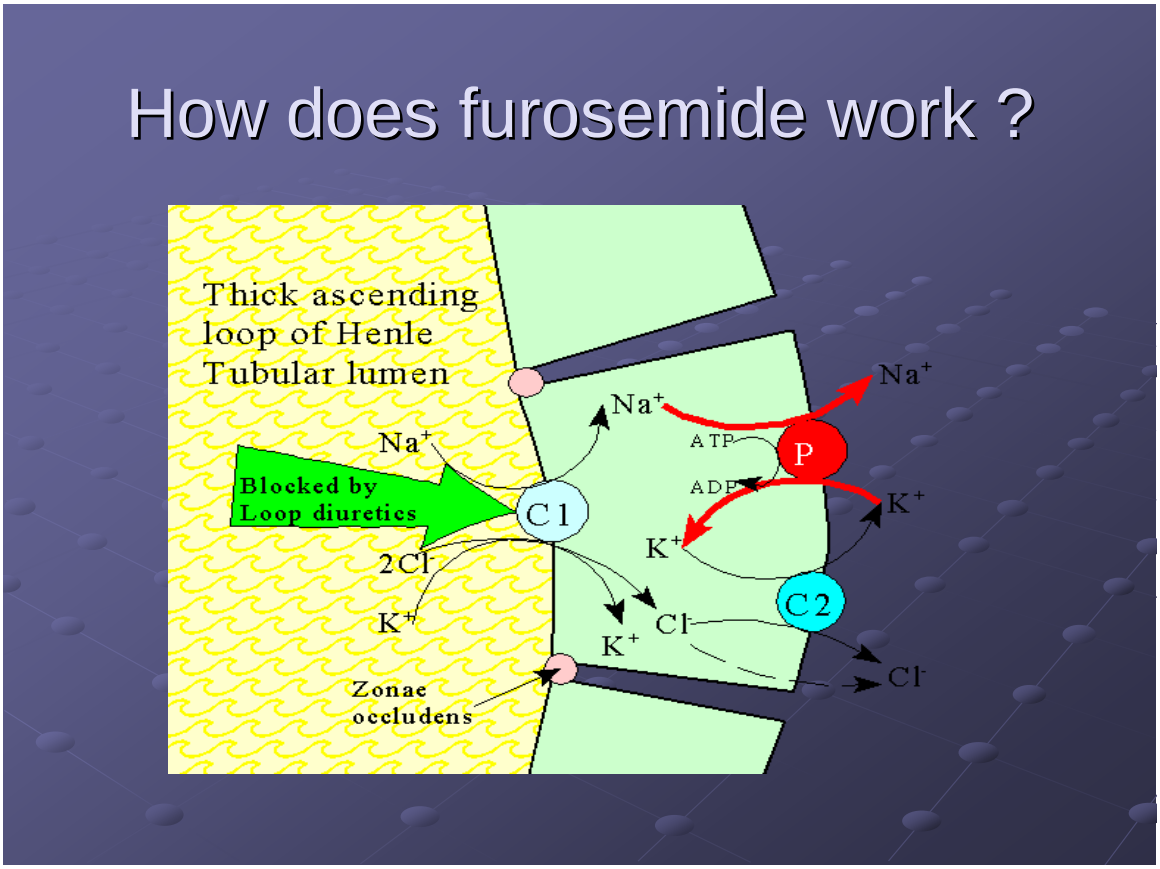
Lithium increases urine output in high serum concentrations, decreasing GFR, and reducing the ability of urine to concentrate. (Nb. It is rare we would see a patient in ICU on this drug).

Contrast media *affects patients with pre-existing renal impairment commonly leading to acute renal failure. The exact mechanism is not clearly understood, but it is thought to be nephrotoxic to epithelial cells of the kidney. The problem is exacerbated in diabetic patients with impaired renal function. In cases where contrast imaging is absolutely necessary some prophylactic administration of fluid bolus of normal saline may be utilised (Saker, 2000). Acetylcysteine (the paracetemol reversal agent) may also be given, to protect the kidney and to reduce the risk of further damage from contrast media.*

Analgesic nephropathy

Chronic interstitial nephritis and papillary necrosis can develop as a consequence of long-term abuse of combination analgesics (Saker, 2000).

A further word on furosemide use.



(Author not found)

Furosemide is known as a 'loop diuretic' because it affects the loop of Henle. It works by increasing the amount of salt and water excreted in urine, by blocking the reabsorption of sodium (Na+) into the renal capillaries. This promotes a natriuresis, and passive water loss.

Note;

- 70-90% of filtered sodium is normally re-absorbed in the proximal convoluted tubules (PCT)**.**
- Furosemide works on receptors on the inside of the tubule to block sodium reabsorption**.**
- Furosemide can only work if there is adequate glomerular filtration. There is considerable debate over the use of furosemide in renal failure. The use of furosemide as a therapy for intensive care patients with renal impairment is controversial.

Furosemide can cause harm:

- Volume contraction
- Ototoxicity
- Hypokalaemia
- Hypomagnesaemia
- Metabolic alkalosis

- Thrombocytopoenia, leukopoenia, anaemia
- GIT “upset”
- Metabolic: uric acid↑, hyperglycaemia
- Nephrotoxicity

(Howard, G., 2004).

References

Saker B. (2000). Everyday drug therapies affecting the kidneys. *Australian Prescriber, 23 (1);* 17-19. Retrieved on 29 Sept, 2013 from **http://www.australianprescriber.com/magazine/23/1/17/9/**

Howard, G. (2004). Applied renal physiology or whatever. Powerpoint educational material. *Hamilton, New Zealand; Waikato District Health Board (unpublished).*