Learning Package

Health
Hunter New England
Local Health District

Renal: Introduction to Peritoneal Dialysis (PD)

Sites where Learning package applies	Clinical areas where care is provided to patients with Kidney disease
Description	This learning package provides an overview of the basics of Peritoneal Dialysis
Target audience	Nephrology and Non- Nephrology clinical staff who provide care to Peritoneal Dialysis patients.
Learning Outcomes, On completion of this package you will be better able to:	• Describe the basic anatomy and physiology of the peritoneum • Discuss the principles of dialysis (including: diffusion, osmosis and ultrafiltration) as they apply to PD and the factors that influence these principles. • Describe PD access and identify best practise for the care of the PD catheter and PD catheter exit site. • Identify PD equipment and PD therapy options. • Explore the care of patients undergoing PD including: factors affecting patient selection and patient choice for PD therapy; patient home therapy training and importance of ongoing education; adequacy of PD and general PD patient care. • Describe the complications of PD and the associated nursing management.

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Related Legislation, Australian Standard, NSW Ministry of Health Policy Directive or Guideline, National Safety and Quality Health Service Standard (NSQHSS) and/or other, HNE Health Document, Professional Guideline, Code of Practice or Ethics:

- Infection Prevention and Control Policy [PD2017_013]
- NSW Health Policy PD 2005_406 Consent to Medical Treatment http://www.health.nsw.gov.au/policies/PD/2005/pdf/PD2005_406.pdf
- Renal Guidelines and Procedures http://ppg.hne.health.nsw.gov.au/

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Renal: Introduction to Peritoneal Dialysis (PD)

Learning Package
2018

NSW GOVERNMENT
Health
Hunter New England
Local Health District

Purpose: *To enhance the knowledge of Nephrology and Non- Nephrology clinical staff who provide care to Peritoneal Dialysis patients.*

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Introduction
This learning package is one of a suite of renal packages aimed at providing resources for nephrology and non-nephrology staff to enhance their clinical skills and knowledge in the care of dialysis patients. This package aims to outline the baseline theoretical knowledge of anatomy, physiology of the peritoneal membrane, principles of dialysis, dialysis equipment and components of management of PD patients that underpins the care practices for these patients.

Disclaimer
This learning package has been prepared by health professionals employed in Hunter New England Local Health District in the renal services. While all care has been taken to ensure that the information is accurate at the time of development, the authors recommend that all information is thoroughly checked before use if utilised by another unit, context or organisation.

Naming Convention
Renal: Introduction to Peritoneal Dialysis (PD)

Aim
To enhance the knowledge of Nephrology and Non- Nephrology clinical staff who provide care to Peritoneal Dialysis patients.

Learning Outcomes or Learning Objectives
Following the completion of this learning package, the learner will be able to:
- Describe the basic anatomy and physiology of the peritoneum.
- Discuss the principles of dialysis (including: diffusion, osmosis and ultrafiltration) as they apply to PD and the factors that influence these principles.
- Describe PD access and identify best practise for the care of the PD catheter and PD catheter exit site.
- Identify PD equipment and PD therapy options.
- Explore the care of patients undergoing PD including: factors affecting patient selection and patient choice for PD therapy; patient home therapy training and importance of ongoing education; adequacy of PD and general PD patient care.
- Describe the complications of PD and the associated nursing management.

Pre-requisites
There are no formal prior learning requirements to undertake this learning package. This is entry level information for staff beginning work in the area of nephrology nursing or caring for peritoneal dialysis patients. However review of the anatomy, physiology and normal functions of the renal system will assist your understanding of the impact of end stage kidney disease on these patients.

Learning Package Outline

The package is designed to be a self-directed learning experience that will guide you through the literature and clinical issues related to peritoneal dialysis.
This package is developed within an adult learning framework so not all activities need to be documented but it is expected that you will complete them in order to facilitate your learning.

Problem based learning

This program is based on a problem-based approach to learning. This approach has been chosen to enhance critical thinking, and to create a body of knowledge that staff caring for peritoneal dialysis patients can apply to practice.

Instructions for participants

Completion of this package is equivalent to 5 Continuing Professional Development (CPD) hours which is a requirement for National Registration. Evidence of CPD can be generated using the Reflection on learning page at the end of the template.

Throughout this self-directed learning package there are readings and activities that you will need to complete. You can access the readings online (journal articles, guidelines and procedures) through CIAP, the HNELHD Intranet or via your HNELHD library. The Wansey Dialysis Centre – training manual for peritoneal dialysis can be accessed via the information in Appendix 2. You will be provided with information on how to access the readings in Appendix 2. The online readings are not provided within this document due to copyright law restrictions. If you have any difficulty locating the readings please seek assistance from your hospital / health facility library or the NE/CNE/CNS/CNC for your area. There is a suggested Additional resource list and it is by no means complete. Please read widely to facilitate your learning.

This Learning Package uses the following icons:

	**READING** **This icon alerts you to undertake reading related to the subject**
	**LEARNING ACTIVITY** **This icon denotes a learning activity that you will need to complete**
	**GUIDELINES** **This icon alerts you to the presence of a guideline or procedure related to the subject**

Assessment process
When completed, you can return the package assessment activities to the relevant NE / CNE / CNS/ CNC who will discuss it with you.

Recommended Readings
Essential and additional suggested readings are identified in the relevant sections of the package.

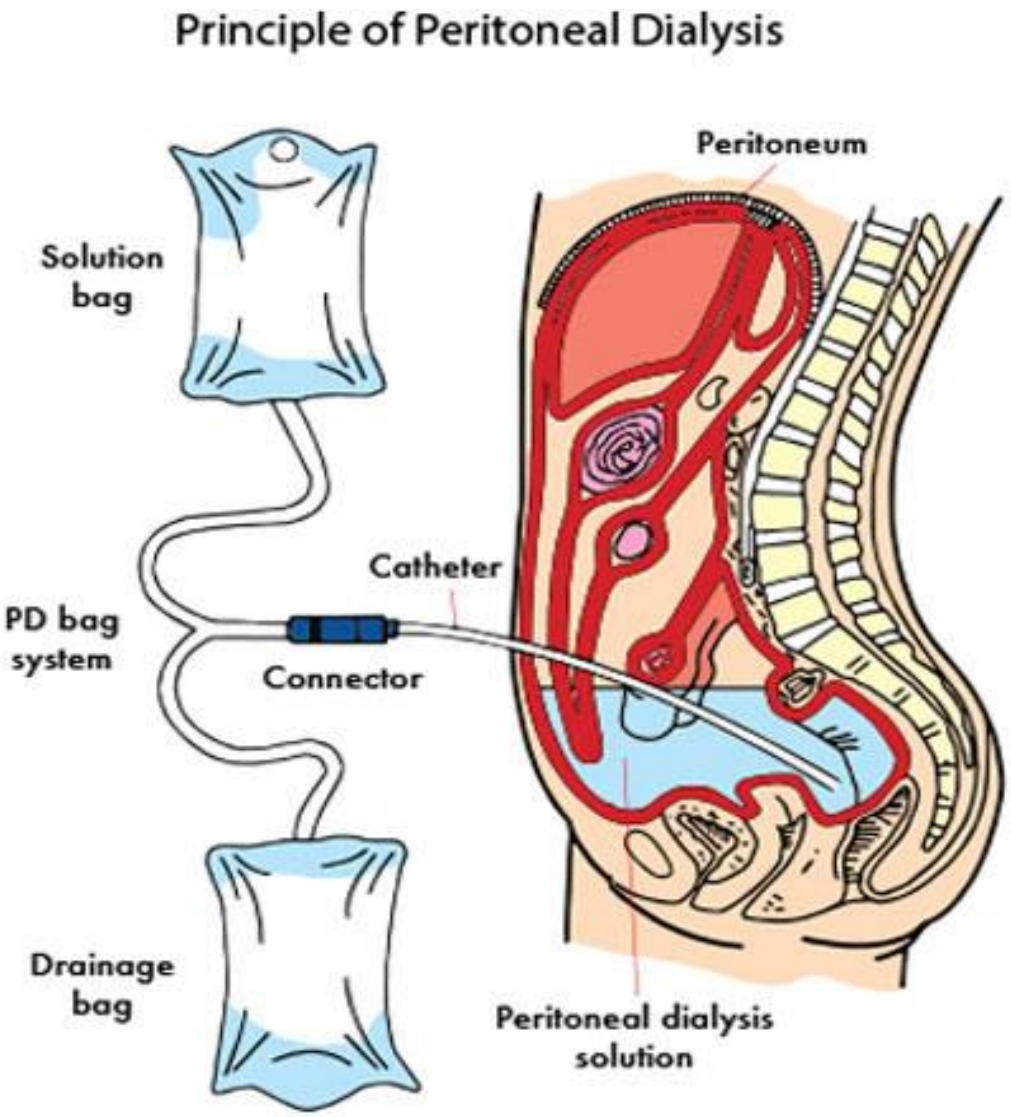
Evaluation
A Learning Package Evaluation form for you to complete when you have finished the package is included on page 62. Please return the completed evaluation to your relevant NE/CNE/CNS/CNC. All feedback is appreciated and assists in development and review of the learning package.

OVERVIEW OF PERITIONEAL DIALYSIS

The renal system plays a significant role and performs many functions in the maintenance of homeostasis in the body. When a patient reaches end stage kidney disease (ESKD) they are unable to maintain homeostasis without medical intervention. Medical intervention options for treatment of ESKD include introducing renal replacement therapy, to substitute for some of the functions of the kidney. Peritoneal Dialysis (PD) is one type of renal replacement therapy.

Peritoneal dialysis involves infusing a dialysis solution into the peritoneal cavity where the principles and processes of dialysis take place. See Figure 1 below.

Figure 1: Basic equipment and process of PD



Picture Source: National Kidney Foundation – What is Peritoneal Dialysis?

The main types of peritoneal dialysis therapy are Continuous Ambulatory Peritoneal Dialysis (CAPD) – shown in Figure 1, and Automated Peritoneal Dialysis (APD). The principles of dialysis, CAPD and APD will be discussed in more detail in the following sections.

Peritoneal dialysis can be used for treatment in Acute Kidney Injury, but is usually one of the therapy options for chronic kidney disease patients who have reached end stage kidney disease.
The specific use of peritoneal dialysis for Acute Kidney Injury will not be included in this package.

INITIATION OF PERITONEAL DIALYSIS

As peritoneal dialysis is primarily a home based therapy, patient selection is an important first step. In HNELHD assessment of the patient and information on therapy options and choices are provided to the patient via the Renal Options Program. It is advantageous for the patient to participate in this program as it can identify any potential problems prior to treatment initiation and enables the patient to make informed decisions about a suitable therapy choice.

Potential Contraindications for Peritoneal Dialysis

Patients who meet any or all of the following criteria may not be acceptable candidates for peritoneal dialysis

1. Morbidly obese (BMI >40)
2. A history of multiple abdominal surgeries – with high risk of adhesions and or peritoneal membrane impairment.
3. Aortic aneurysms
4. Patent opening between the peritoneal and pleural cavities.
5. Previous failed peritoneal dialysis.
6. Active abdominal wall infection.
7. History of bowel disease, e.g. colitis, diverticulitis, colostomy.
8. Severe respiratory disease

(Kallenbach, 2016; Harris, Elder, Kairaitis & Rangan, 2013, University of Rochester Medical Center Rochester, NY 2017)

The decision for peritoneal dialysis is made in consultation with the Multidisciplinary Renal Care team, patient and patient's family/carer. Factors considered include: relevant medical contraindications, psychosocial, environmental, cognitive, physical, work, lifestyle and patient's personal preference (Kallenbach, 2016).

READING

1. Kidney Health Australia (KHA) Introduction to PD – This is specifically designed for people who are considering treatment options for kidney disease.

Read pages 32 – 35 "How do I Make the Choice"

http://kidney.org.au/cms_uploads/docs/rrc-introduction-to-peritoneal-dialysis.pdf

LEARNING ACTIVITY

1. List advantages and potential disadvantages of PD therapy.

OPTIONAL ACTIVITY

In your local service speak to the Renal Options Coordinator and identify what patient problems may need intervention prior to the patient starting PD.

THE PERITONEUM – Basic Anatomy and Physiology

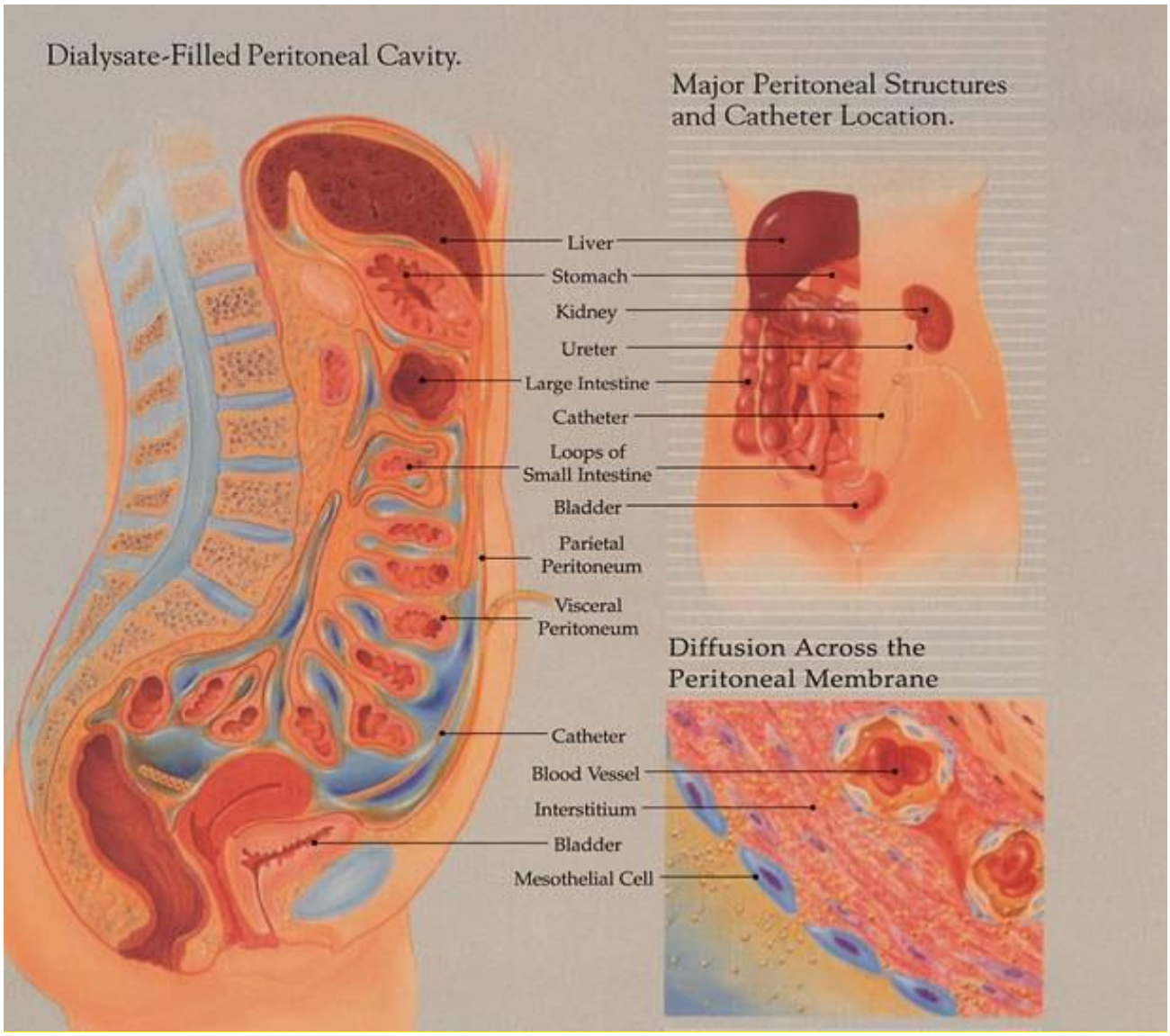
To understand the mechanism by which peritoneal dialysis works it is important to understand the peritoneal anatomy. The peritoneum is a serous membrane, lining the abdominal cavity and organs. It has a surface area approximately equal to the body's surface area averaging 1.73m^2 in adults. The membrane of the peritoneum is continuous and closed in males, but in the female the ovaries and the fallopian tubes open into the peritoneal cavity (Kallenbach, 2016). The peritoneal cavity is therefore best described as sac-like. It contains approximately 50-100mls of transudate that acts as a lubricant to prevent friction between the folds of the peritoneal membrane (Thomas, 2014).

The peritoneal membrane is comprised of two parts.

1. The visceral membrane that covers the abdominal organs and other viscera.
2. The parietal membrane that lines the walls of the abdomen

The peritoneal membrane is highly vascular with a vast network of tiny blood vessels suspended in connective tissue. The visceral peritoneal membrane receives its blood supply from the superior mesenteric artery, and venous drainage is via the portal system. The parietal peritoneal membrane receives blood from the lumbar, intercostal and epigastric arteries and drains by the inferior vena cava. Total peritoneal blood supply is estimated to be 50-100mL per minute (Daugirdas, Blake & Ing, 2015). Lymphatic drainage of the peritoneum and peritoneal cavity serves to return excess fluid and proteins into the circulatory system and to remove foreign bodies from the peritoneal cavity (Thomas, 2014). See Figure 2, identifying the peritoneal structure and membrane mechanism.

Figure 2: Abdominal cavity



Picture source: www.advancedrenaleducation.com

The peritoneum is ideal for dialysis because of its sac-like formation, which has the ability to hold dialysis solution that is infused into the peritoneal cavity, and its highly vascularised structure. The peritoneal membrane serves as the semi-permeable membrane allowing for the principles of dialysis - osmosis, diffusion and ultrafiltration to occur.

THE PRINCIPLES OF DIALYSIS

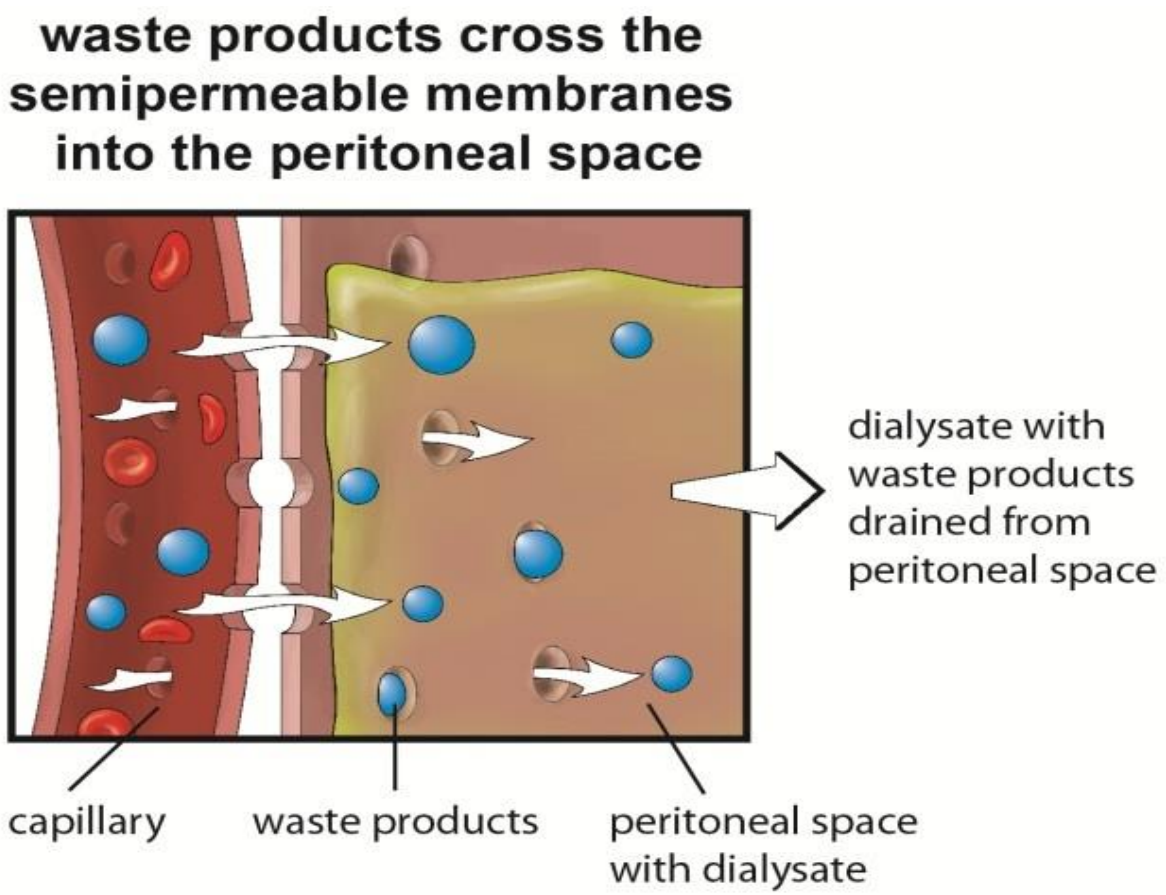
Dialysis can be defined as the removal of waste products, molecules and fluid from the body across a semi-permeable membrane. Haemodialysis and peritoneal dialysis (PD) utilise the same principles, only the application of the principles is different. The principles of dialysis are: diffusion; osmosis; ultrafiltration and convection (Thomas, 2014).

Semi-permeable Membrane – a membrane that is freely permeable to water and small ions or molecules, but not to larger molecules or plasma proteins

Diffusion – the primary mechanism of waste removal in peritoneal dialysis. Diffusion is the bi-directional movement of solutes across a semi-permeable membrane from an area of higher concentration to an area of lower concentration. Solutes move from blood to dialysate, dialysate to blood (Thomas, 2014).

Solutes continue to move until equilibrium is established. The time it takes for equilibrium to occur depends on the individual patient as well as the size of the solute. Smaller solutes move more rapidly than larger solutes.

Figure 3: The Principle of Diffusion



Picture source www.emaze.com

Factors that influence diffusion:

1. Peritoneal membrane size or available area – the size of the membrane can be reduced by scaring or adhesions.
2. Peritoneal membrane permeability – inflammation, infection, vascular disease, collagen disease, medications, or membrane abnormalities decrease the membrane permeability.
3. Solute characteristics – the smaller the solute the faster the movement.
4. Concentration gradient – the greater the concentration difference between the blood and the dialysate, the faster solutes move.
5. Dwell time of the dialysate – time dialysate remains in the peritoneal cavity. Intrinsic solute transport characteristics of an individual's peritoneal membrane mean that equilibrium will be established at shorter or longer dwell times.
6. Dialysate volume – The more exchanges performed or increasing dialysate volume infused into the peritoneum per exchange increases diffusion.
7. Dialysis solution temperature – if the solution is less than body temp it takes time to warm the solution, thus delaying the onset of diffusion. It is therefore important to warm dialysis solution prior to use.

(Levey, Brown & Lawrence 2016; Daugirdas *et al.* 2015; Thomas, 2014; Mahon, Jenkins & Burnapp, 2013)

Osmosis – is the movement of water through a semi-permeable membrane from an area of low solute concentration to an area of high solute concentration along an osmotic gradient (Thomas, 2014).

Ultrafiltration – describes the movement of fluid across the peritoneal membrane and occurs as a consequence of the osmotic gradient between dialysis solution (containing an osmotic agent such as glucose, amino acids or Icodextrin™) and the peritoneal capillary blood. (Daugirdas, *et al.* 2015)

For example: When a dialysis solution (containing glucose) is placed in the peritoneum, the dialysis solution has higher glucose content than blood. The blood contains more water molecules per glucose molecule than that of the dialysis solution. The glucose in the dialysis solution thus pulls water molecules from the blood into the dialysis solution in an attempt to equalize the number of water molecules (osmosis). The glucose creates an osmotic pressure gradient between the dialysis solution and the blood. The higher the glucose content the higher the osmotic gradient. The ultrafiltration rate is the highest at the beginning of each peritoneal dialysis exchange when the osmotic gradient is the highest.

Factors that influence Ultrafiltration are:

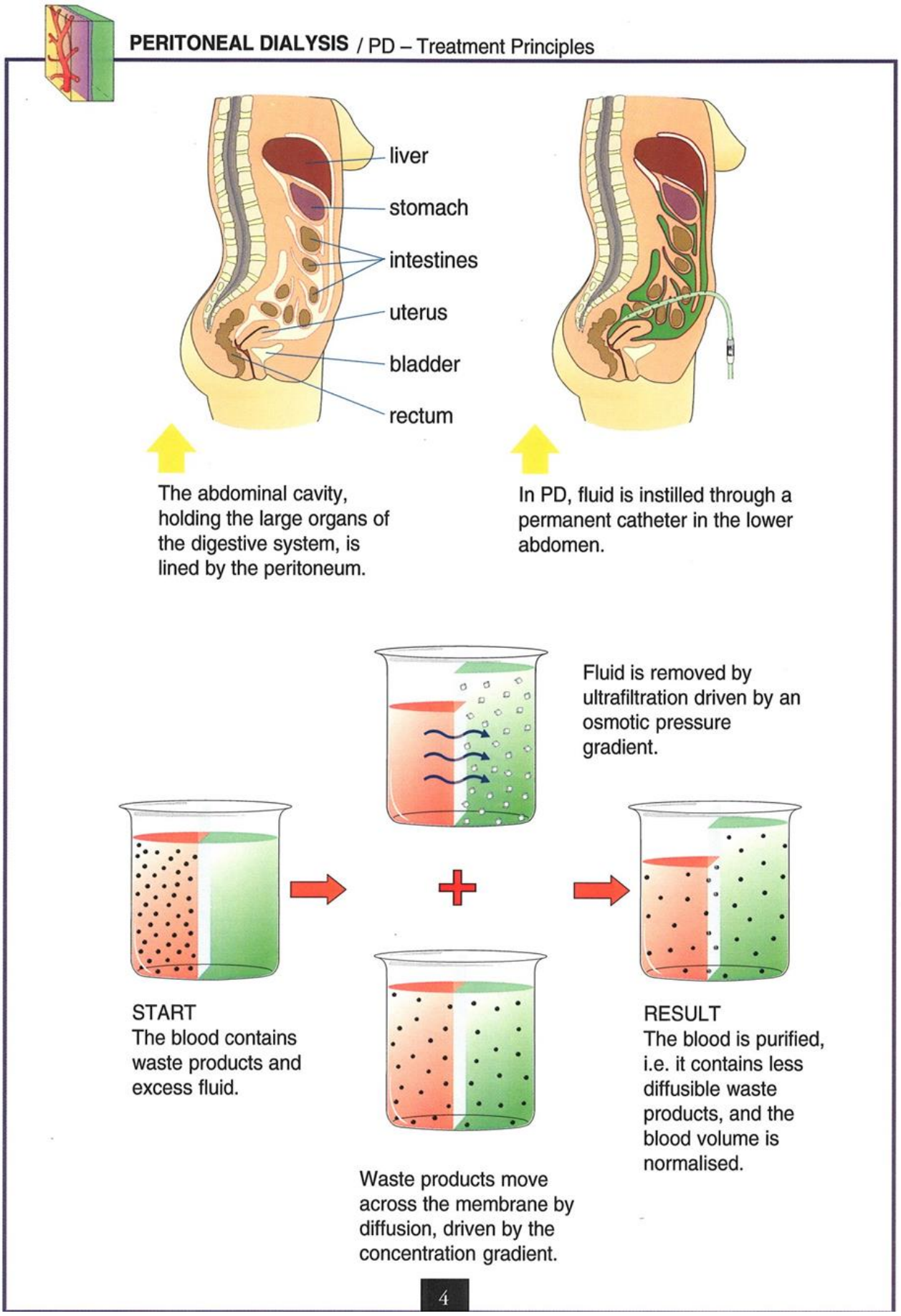
1. Functional peritoneal membrane surface area.
2. Peritoneal membrane permeability.
3. Osmotic pressure gradient.
4. Oncotic pressure gradient – pressure exerted by larger molecules (particularly proteins) which acts to keep fluid in the blood.
5. Hydrostatic pressure gradient – pressure exerted at equilibrium as a result of gravity forces. This gradient is active between the peritoneal capillary pressure and the intra-peritoneal pressure. It is impacted by the intravascular volume status of the patient vs changes in the patient's intraperitoneal pressure. Raised intraperitoneal pressure (e.g. increased dialysis solution dwell volumes, constipation, or when the patient is seated or standing) will decrease ultrafiltration.
6. Dwell time of the dialysate – decreasing dwell time of the dialysate in the abdominal cavity can also increase the amount of fluid removed with ultrafiltration.

(Daugirdas, *et al.* 2015; Mahon, *et al.* 2013; Nissen & Fine, 2017)

Convection (Solute Drag) – is when fluid moves under ultrafiltration from one solution to another across a semi-permeable membrane some small to medium sized molecules/solutes are dragged with the fluid across the semi-permeable membrane. The amount of solutes that move this way is very small but it is essential to recognize that it does happen (Thomas, 2014).

Equilibrium will occur when the osmolality (the amount of solutes) of the blood and the dialysis solution are equal. Reabsorption of water from the dialysis solution into the blood can occur if the dialysis solution is allowed to dwell past the osmotic equilibrium.
A summary of these combined treatment principles is shown in Figure 4.

Figure 4: PD Treatment Principles.



Picture source: Baxter Healthcare

READING

2. Ellis, P. (2015) Understanding peritoneal dialysis: an intrinsic part of safe patient care. *Journal of Renal Nursing* 7(4), 162 – 166

**See Appendix 1 for information on accessing readings / resources

LEARNING ACTIVITY

2. From P Ellis's article:

i) Identify the main roles of dialysis.
ii) List the main waste products removed during dialysis
iii) Identify the main electrolytes in the patient's blood that dialysis works to normalise by: A) Increasing the levels in the blood, or B) decreasing the levels in the blood.

PERITONEAL DIALYSIS ACCESS

Before peritoneal dialysis can proceed there needs to be access to the peritoneal cavity and this is achieved via the placement of an indwelling catheter. The catheter for both acute and chronic peritoneal dialysis must transport fluid into and out of the peritoneal cavity as quickly as possible and be biocompatible (maintain normal structure and function of the tissues near the PD catheter and tract). (Kallenbach 2016, p. 258)

There are two types of catheters available for peritoneal dialysis: the rigid stylet catheter that is used for acute peritoneal dialysis, and is now rarely seen, and the flexible chronic catheter that is usually made of silicone. Catheters for acute PD use will not be discussed.

The chronic catheter is commonly referred to as a Tenckhoff Catheter and is made of radiopaque material or has a strip that allows for visualization on X-ray. Catheters come in a variety of shapes and sizes from neonatal to adult. The most common catheters are straight, coiled, or swan necked in shape. Chronic catheters usually have Dacron or polyester cuffs which provide material for body tissue ingrowth that stabilize the catheter. The cuffs limit outward movement of the catheter, provide a barrier from micro-organisms, and prevent fluid leaks. Catheters can be single or double cuffed (Daugirdas, *et al.* 2015; Kallenbach, 2016; and Nissen *et al.* 2017). See figures 5 - 7 for common catheters used in HNELHD.

Figure 5: Adult Curl Cath 2 Cuff Tenckhoff catheter

Figure 6: Swan Neck 2 Cuff Tenckhoff catheter

Figure 7: Straight, 2 Cuff Tenckhoff Catheter

Pictures provided by Baxter Healthcare – Product guide.

"The PD catheter is the patient's "lifeline" and is essential for long-term patient success with peritoneal dialysis. Proper placement of the catheter and postoperative care of the healing exit site are vital for a successful permanent peritoneal access". (Baxter Professional – The Catheter Matters)

As patients come in all shapes and sizes it is important to examine the patients abdomen and mark the peritoneal catheter exit site prior to catheter insertion, so that the catheter exit site is in an optimal position. The patient should be assessed while sitting, lying and standing.

Some factors to consider when an exit site is being marked include: patients ability to visualise the PD catheter exit site, patient's belt line, obesity, skin creases/folds, presence of scars, chronic skin conditions, incontinence, physical limitations and occupation. (Daugirdas, *et al.* 2015). See Figure 8, showing a "Perfect" PD catheter exit site classification, according to Twardowski, 1996 – "Classification of normal and diseased exit sites".

Figure 8: An example of a healthy chronic exit site due to optimal exit site marking, insertion technique, post-operative and chronic daily exit site care.

Picture Source: HNELHD Guidelines and Procedures

The Tenckhoff catheter can be inserted in the peritoneum by an open surgical procedure, laparoscopically, percutaneous needle-guidewire technique or via peritoneoscopy.

The catheter tip (fenestrated end) should be directed towards the tip of the pelvis. The first Dacron cuff should be positioned in the rectus abdominis or buried between the peritoneum and the muscle. The subcutaneous catheter segment tunnels from the peritoneal membrane through the muscle and subcutaneous fat to the external environment. This route is referred to as the “tunnel”. The second Dacron cuff is located in this tunnel (see Figure 9) and should be at least 2cm from the skin surface. The site at which the catheter emerges from the skin is called the “exit site”. This exit hole needs to be as small as possible to promote rapid healing. Ideally the exit site should be directed downwards to minimise the collection of debris in the sinus, which may result in infection. (Harris, *et al,* 2013; Nissen, *et al,* 2017)

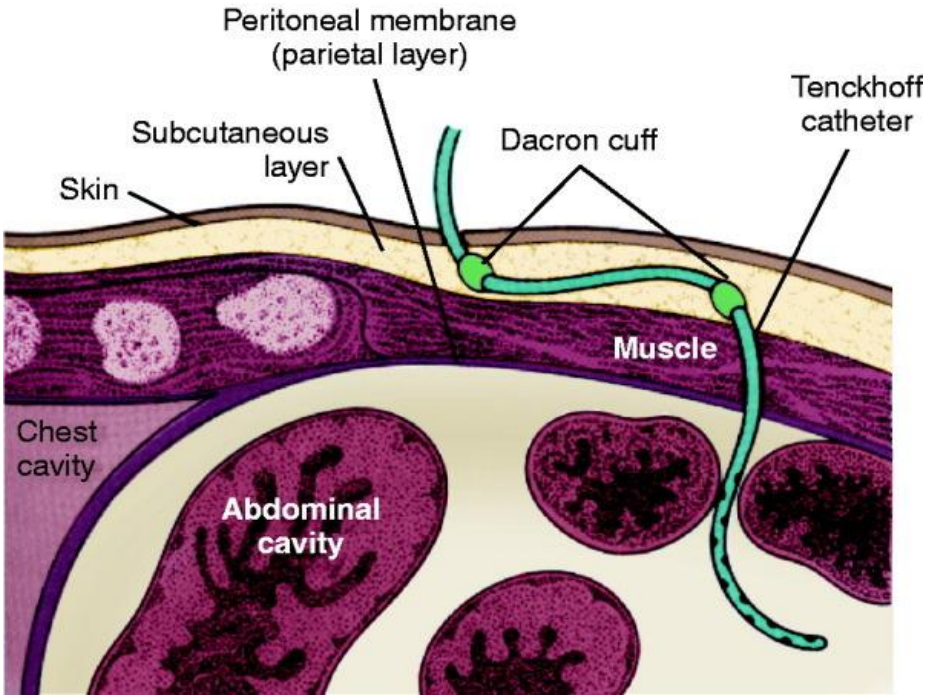


Figure 9: Tenckhoff catheter diagram showing location of internal catheter and internal cuffs

Picture source: Lewis SL *et.al*: Medical-surgical nursing assessment and management of clinical problems, ed 7, St Louis, 2007, Mosby.)

The catheter when placed in the peritoneum can be checked for position by radiography - plain abdominal X-ray if required. See Figures 10 & 11 for examples of x-ray image showing the internal position of PD catheters:

Figure 10: Catheter tip in pelvis, with some kinks and loop identified

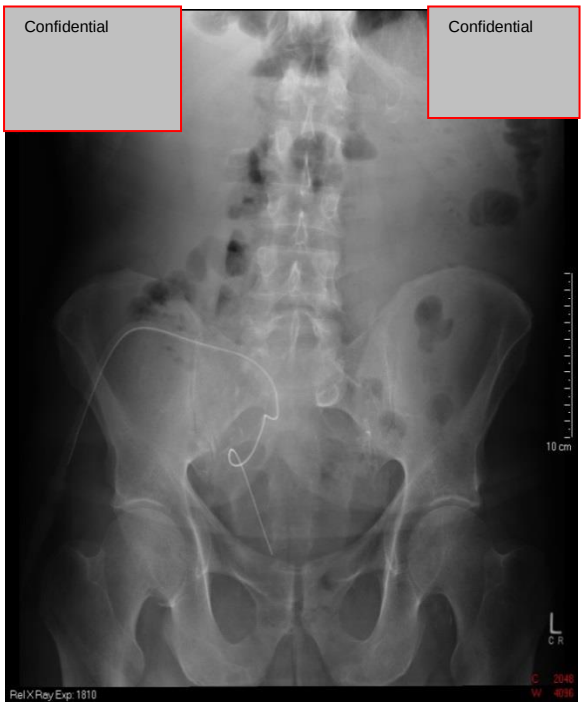
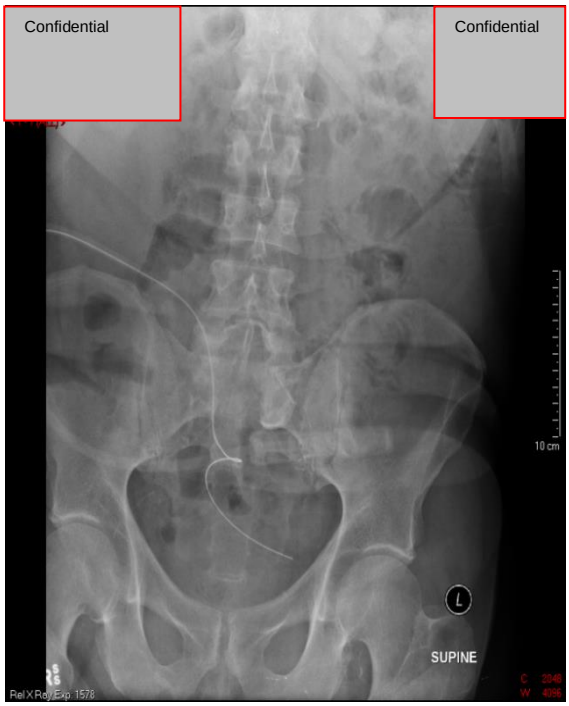


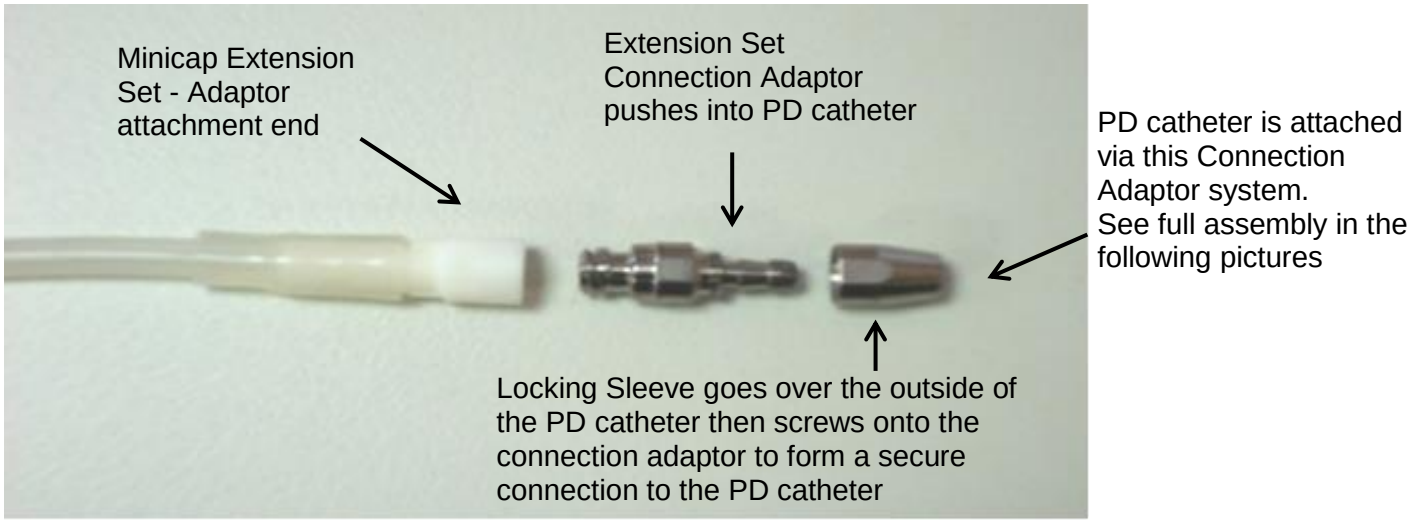
Figure 11: Catheter tip over the left side of pelvis and formed a tight loop in the catheter



Pictures source: HNELHD Radiology

A catheter adapter is connected to the end of the peritoneal dialysis catheter to provide a means of joining the catheter to the exchange set. This in turn allows the mechanics of peritoneal dialysis to be performed. See Figure 12 below.

Figure 12: Baxter Locking Titanium Adapter and connection end of Extension Set



Picture source: HNELHD Guidelines and Procedures

After insertion the catheter needs to be immobilised so that there is no trauma on the exit site and healing is allowed to take place. If possible the catheter should not be used for the first two weeks after insertion to prevent complications from early use. This delayed use also allows time for healing and epithelial growth.

After initial healing, assessment and routine care of the PD catheter exit site needs to be performed every day by the nurse initially and then by the patient. The nurse also needs to assess the patients exit site at every visit to the clinic (Kallenbach, 2016). See Figure 13 below.

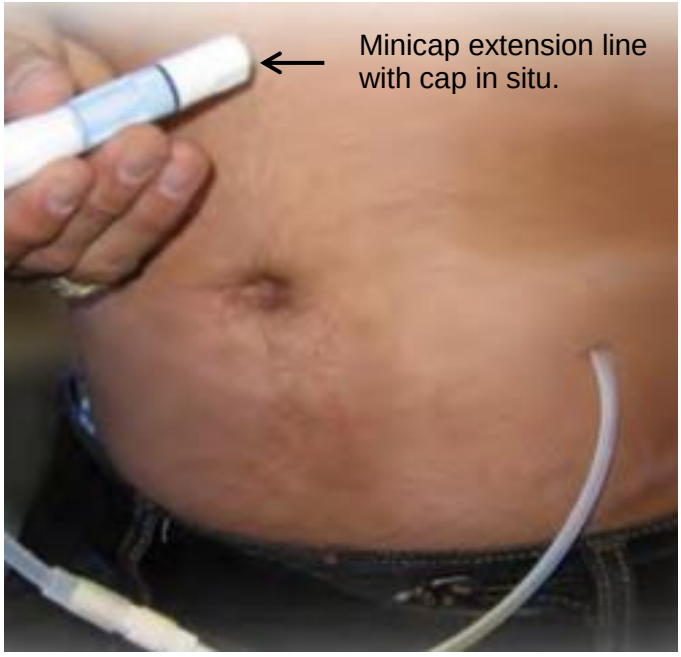


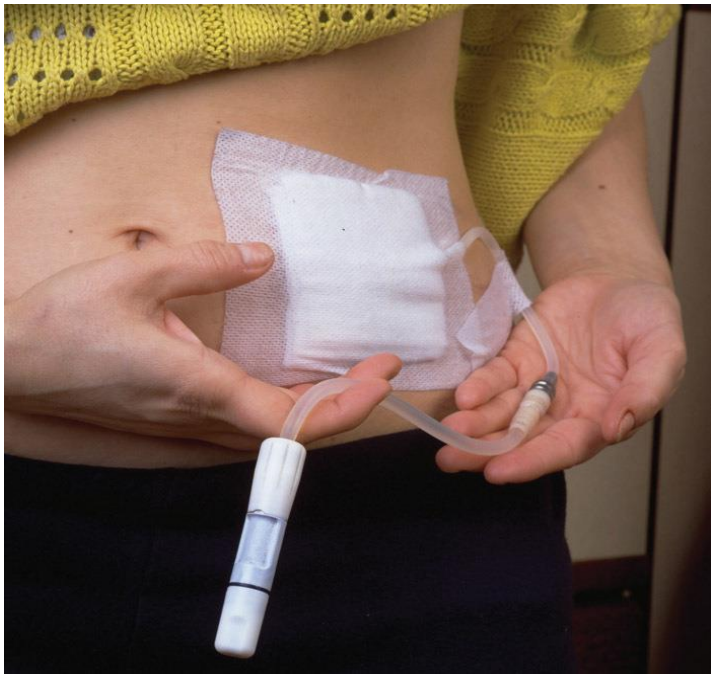
Figure 13: A well healed chronic PD catheter exit site with a minicap extension line attached to the catheter enabling the mechanics of peritoneal dialysis to be performed.

Picture source: Baxter Healthcare

When assessing the exit site, there are a few characteristics that should be examined. It is important to determine whether inflammation is present; the degree of redness of the skin and the size or diameter of the inflamed area, presence of crust, external exudate and drainage, as well as external or internal granulation. Assessment by palpation provides additional information not attained from visualization alone, especially to check for internal secretion. An exit-site infection can be limited to the exit site or may extend into the subcutaneous tunnel causing a tunnel infection. (advancedrenaleducation.com /content/classifying-exit-sites-and-diagnosing-exit-site-infections - 2016)
Catheter exit sites are classified based on clinical criteria according to guidelines outlined by Teixidó or Twardowski. See http://advancedrenaleducation.com/content/classifying-exit-sites-and-diagnosing-exit-site-infections for more information.

The usual routine for chronic PD catheter exit site care is for a clean dressing to be applied daily post patient showering. This provides both protection for the PD catheter exit site and a secure anchor point to prevent movement trauma to the PD catheter exit site. See Figure 14 below.

Figure 14: Example of daily dressing applied to PD catheter exit site.



Picture source: Kidney Health Australia.

More information on different types of peritoneal catheters, insertion techniques, patient preparation and follow up care can be found in the Additional resources list at the end of this package.

GUIDELINES

1. Locate the HNELHD Guidelines and Procedures.

a) Renal: Peritoneal Dialysis Catheter – Acute (Post Insertion) Exit Site Care
b) Renal: Peritoneal Dialysis Catheter – Chronic Exit Site Care and
c) Wansey Dialysis Centre - training manual for Peritoneal Dialysis 2016.

i) List the key activities that contribute to and maintain a healthy PD catheter exit site
ii) Compare the patient routine chronic PD catheter exit site dressing procedure (from the Wansey Dialysis Centre Manual) with the hospital guideline and procedure – what are the similarities and differences

**See Appendix 1 for information on accessing readings / resources

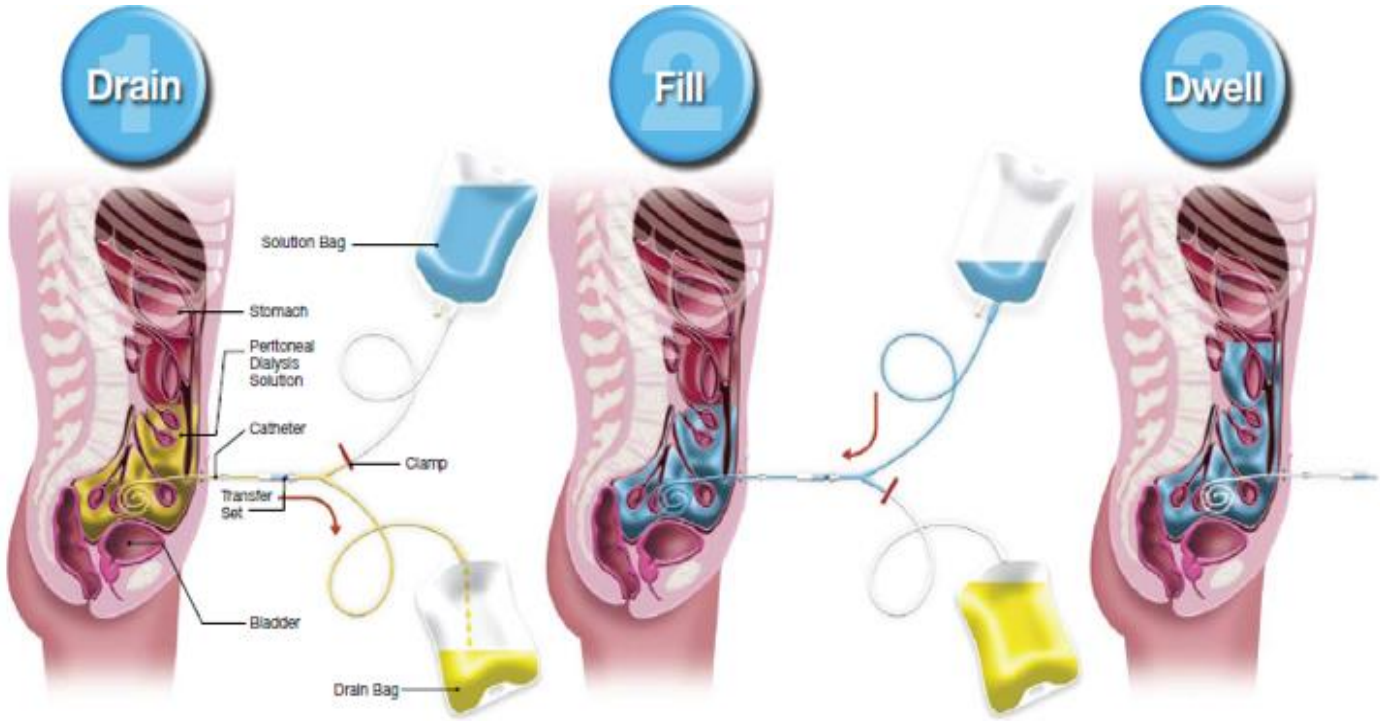
TYPES OF PERITONEAL DIALYSIS

Peritoneal dialysis can be performed by either manual or automated means. Patients are generally commenced on manual exchanges before evaluation of their peritoneal membrane by a Peritoneal Equilibration Test (PET) which will then indicate if the patient is

suitable for automated dialysis. Occasionally patient circumstances dictate which method will be used.
Manual: each solution exchange is performed manually by the patient/nurse/caregiver. Four cycles (exchanges) are generally performed each day but can be more or less depending upon individual requirements.
Automated: exchanges/cycles are performed by a machine (cycler) that has been programmed with the treatment regime. The cycler warms, infuses, dwells, drains and monitors dialysis fluid volumes and dwell times. The patient is normally connected to the machine for 8-12 hour intervals; usually at night while the patient sleeps (Kallenbach, 2016).

A cycle or exchange normally contains the phases in the order listed. See Figure 15.
1. Drain: the effluent (used dialysis solution) is removed from the peritoneum.
2. Fill: the infusion of new dialysis solution into the peritoneum.
3. Dwell: The time the dialysis solution is left in the peritoneum before the next drain.

Figure 15: The phases of a PD exchange



Picture source: Baxter Healthcare

Methods of Peritoneal Dialysis

CAPD (continuous ambulatory peritoneal dialysis) is manual peritoneal dialysis that is performed by the patient or carer every day. The patient always has dialysis solution in their peritoneum, apart from drain and fill cycles. The patient usually performs 4 to 6 exchanges per day, every 4 to 6 hours, with the night time exchange left to dwell for 8 to 10 hours. Two variations of CAPD include:

- Tidal: Some patients may not drain their peritoneum completely with each exchange. Used for patients who have discomfort/pain on outflow when the peritoneum is empty

- Dry time: Some patient's do not require or cannot have dialysis fluid in their abdomen for the entire 24hrs so they have a period of time with no dialysis fluid in their abdomen

See Figure 16, for an example of CAPD exchange fluid, drain bag and connection system.

Figure 16: Baxter Healthcare - Freeline Solo System for CAPD exchange

Ring Pull

The Ring Pull is removed to connect this end of the Freeline Solo to the patient's minicap extension line.

Picture source: HNELHD Guidelines and Procedures

APD (Automated Peritoneal Dialysis) is a method of machine assisted peritoneal dialysis which occurs over a period of 10 to 24 hours. It is usually performed at night while the patient sleeps. APD uses a cycler machine that is at the patient's bedside. The machine can perform a variable number of exchanges during the prescribed treatment time.

- CCPD (Continuous cyclic peritoneal dialysis): is the most common type of APD. On completion of the night cycling process the machine fills the patient's abdomen one last time and the dialysis solution is allowed to dwell throughout the day. Dialysis solution is always present in the peritoneum, 24 hours a day, apart from drain and infusion.
- NIPD (Nocturnal Intermittent PD): exchanges are performed overnight but there is minimal or no fluid left in the patient's abdomen during the day. This type of treatment is ideal for new PD catheters and patients with problems exacerbated by increased intra-abdominal pressure (e.g. peri-catheter leaks, hernias and patients with poor appetite).

- IPD (Intermittent PD): treatment sessions are performed periodically. The patients' peritoneum is left empty (dry) between treatment sessions.

In addition to CCPD, NIPD or IPD, treatment sessions can be further tailored to meet the patient's needs through either the delivery of high dose peritoneal dialysis or tidal exchanges.

- High Dose: an extra day exchange is added. This is usually in the afternoon prior to connection of night therapy.
- Tidal (TPD): after the initial infusion of dialysis solution, a portion of the dialysis solution is drained and replaced with new solution. Dialysis occurs even during the drain and infusion because a portion of the dialysis solution always remains in the abdomen, increasing solute removal. Tidal peritoneal dialysis is usually associated with automated peritoneal dialysis when utilising a cycler, e.g. Tidal CCPD or hi-dose Tidal (Nissenson *et al.* 2017; Kallenbach, 2016; Daugirdas *et al.* 2015; Thomas 2014).

See Figure 17, for an example of an APD cycler machine, exchange fluid, and connection system.

Figure 17: Baxter Claria Homechoice Cycler

Picture Source: HNELHD Guidelines and Procedures

LEARNING ACTIVITY

3. List the key activities and patient observations that should be attended prior to performing a CAPD exchange.
4. State what actions should be taken if a suspected contamination occurs during
   i) preparation of dialysis equipment for CAPD exchange
   ii) connecting patient to CAPD exchange equipment
   iii) disconnecting patient from CAPD exchange equipment

**See Appendix 1 for information on accessing readings / resources

GUIDELINES

2. Locate the HNELHD Guidelines and Procedures.

i) Renal: Baxter Freeline Solo Continuous Ambulatory Peritoneal Dialysis Exchange
ii) Renal: Fresenius Stay Safe or Balance Continuous Ambulatory Peritoneal Dialysis (CAPD) Exchange and
iii) Wansey Dialysis Centre - training manual for Peritoneal Dialysis 2016.

PERITONEAL DIALYSIS FLUIDS and ADEQUACY

"The basis of PD is the removal of various metabolic products and excess fluid from the patient across the peritoneal membrane by instilling a suitable dialysis solution into the peritoneal cavity. This process can be altered by variations to the composition and volume of dialysis solution used and the duration of "dwell" in the peritoneum." (Nissen, *et al.* 2017, p: 408)

PD Solutions – (dialysate, dialysis fluid)

For adult PD patients dialysis solutions are available in 1.5L to 3.0L volumes for CAPD and 2.5L to 6L volumes for APD. Different companies manufacture different dialysis solutions however the composition of dialysis solutions have three essential similar components:

1. Electrolytes - a common problem encountered by patients with end stage kidney disease is electrolyte disturbances (patient electrolyte levels can be above or below normal ranges). To assist homeostasis dialysis solutions contain key electrolytes such as sodium, calcium, chloride and magnesium.

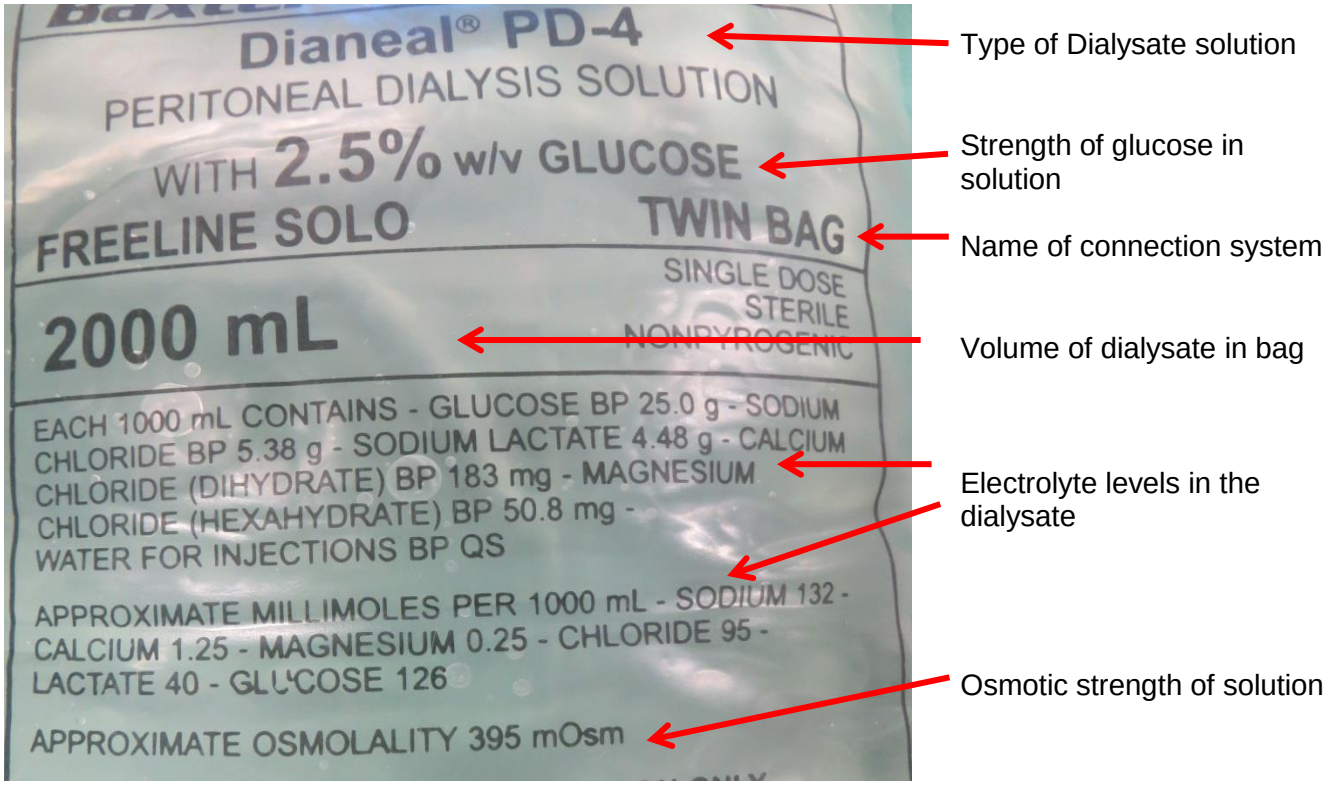
2. Osmotic agents – maintaining normal body fluid balance in patients with end stage kidney disease depends upon the amount of fluid entering a patient's body (e.g: oral intake) versus the amount of fluid able to be removed from the body (e.g: insensible loss and urine output). Patient's urine output usually declines as residual kidney function declines, so excess water removal via dialysis becomes necessary.

Glucose – This is the most common osmotic agent used in dialysis solution as it is relatively safe, inexpensive and provides a source of calories, however it can predispose patients to longer term side effects. The higher the concentration of glucose the greater the osmotic pressure and the greater amount of fluid removed. Dialysis solutions come in varying Glucose concentrations. The 1.5% Glucose will remove little or no fluid, the 2.5% Glucose is hypertonic and will result in moderate fluid removal, and the 4.25% is very hypertonic and results in larger fluid removal.

See Figure 18 for information on dialysis fluid (Dianeal) contents.

ALERT: Frequent use of very hypertonic solutions can lead to peritoneal membrane damage over time and contribute to the consequences of high glucose load on the body. It is essential to consider reducing fluid input / intake if the patient is fluid overloaded rather than just relying on increased dialysis solution strengths.

Figure 18: Example of part of labelling on Baxter Freeline Solo CAPD Glucose Solution Bag



Picture source: HNELHD Tamworth Renal Outreach – teaching resources

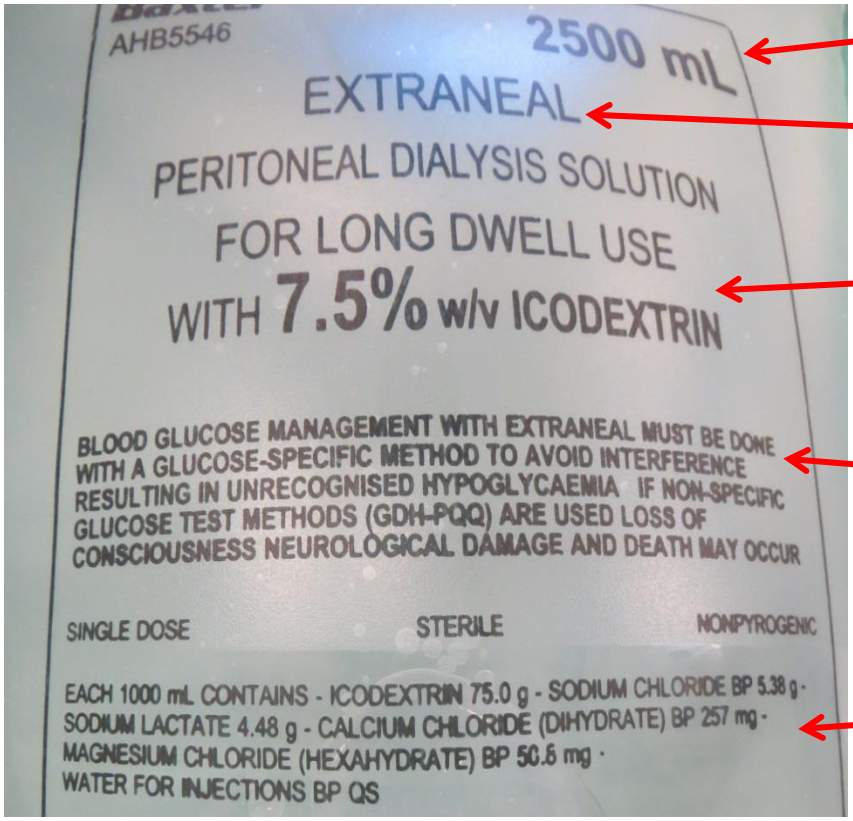
Non- Glucose Solutions

Icodextrin is a glucose polymer preparation with a concentration of 7.5% in solution. It has a slightly lower osmotic pressure than Glucose 1.5% solutions, however because Icodextrin has a larger molecular size than glucose it is absorbed from the peritoneum at a much slower rate. This property means that Icodextrin has a sustained osmotic effect in the patient's peritoneal cavity, over long dwell times (8 – 14hrs) and provides other benefits to the patient, of reducing high glucose load and the subsequent potential consequences.

See Figure 19 for information on dialysis fluid (Extraneal – containing Icodextrin) contents.

ALERT: Icodextrin registered use in Australia is restricted to 1 bag per day and therefore is used in conjunction with glucose based solutions. The metabolite of Icodextrin (Maltose) can interfere with results of some capillary blood glucose measurement on finger prick glucose monitors. Specific glucose monitors/test strips, are therefore required for patient's using Icodextrin solutions.

Figure 19: Example of part of labelling on Baxter Extraneal – containing Icodextrin Solution APD Bag



Volume of dialysate in bag

Type of Dialysate solution

Strength of Icodextrin in solution and description for LONG DWELL USE

Blood glucose testing warning

Electrolyte levels in the dialysate

Picture source: HNELHD Tamworth Renal Outreach – teaching resources

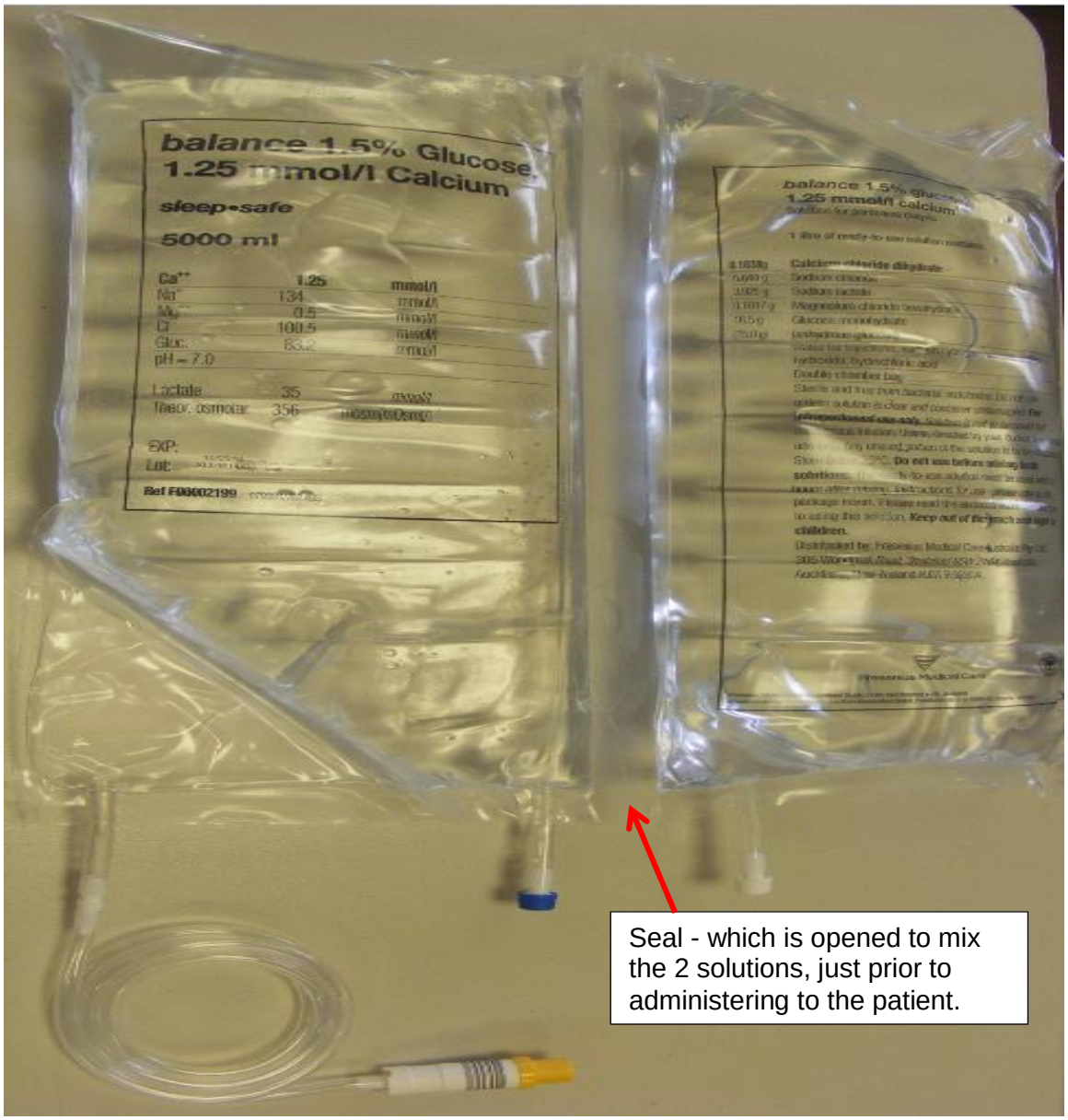
Amino acid-based solutions are used for supplementation to help correct protein malnutrition in nutritionally compromised patients. A 1.1% amino acid-based solution has an osmotic effect similar to Glucose 1.5% solutions. Unfortunately the use of these solutions is associated with causing increased acidosis and urea generation in the patient and is therefore limited to once per day.

3. Acid-Base Buffers – A common complication of end stage kidney disease is metabolic acidosis. The healthy kidney plays a key role in maintaining acid-base balance in the body by excreting hydrogen ions (by-product of normal metabolism) and regenerating bicarbonate. As kidney function is lost bicarbonate must be replaced to prevent the patient becoming acidotic. In PD this is achieved by adding a bicarbonate generating compound (such as Lactate) or bicarbonate to the dialysate solution.

<u>Lactate</u> from the dialysate diffuses across the peritoneal membrane and is metabolised into bicarbonate. See figure 18 and 19 for lactate levels in the dialysate fluid.

Bicarbonate containing dialysate solutions require a two compartment dialysate bag to separate the bicarbonate from the other electrolytes during storage. This prevents the precipitation of the calcium and magnesium out of solution. The two compartment solutions are mixed just prior to patient use. See Figure 20 for an example of a two compartment dialysate bag.

Figure 20: Fresenius Balance Dialysis solution with two compartment dialysate bag



Picture source: HNELHD teaching resources

(Nissen, *et al.* 2017; Kallenbach, 2016; Daugirdas *et al.* 2015; Levey, *et al. 2016;* Baxter Healthcare product information 2017; Fresenius Medical product information 2017).

	GUIDELINES Locate the HNELHD Guidelines and Procedures. 3. Renal: Peritoneal Dialysate and System Selection

LEARNING ACTIVITY

5. What dialysis solutions are available on your unit?
6. What strengths are available?
7. How much ultrafiltration fluid is removed by each dialysate strength on average?
8. Are there any precautions one should observe?

Assessing Adequacy of Peritoneal Dialysis

Patients may use a mixture of dialysis solutions, dialysate strengths and volumes according to their individual needs. This is decided by how the patient's individual peritoneal membrane functions and what is required to achieve adequate dialysis. The aims of adequate dialysis include: assisting maintenance of normal body fluid status, normal electrolyte and acid-base balance and removal of nitrogenous and other waste products, thus reducing the symptoms of uraemia and improving patients' long term morbidity and mortality.

When assessing dialysis adequacy the clinical condition of the patient should be paramount especially as PD is a primarily a home based therapy. A combination of the following parameters must be taken into consideration to determine dialysis adequacy.

- a holistic assessment of the patient, including nutrition and general wellbeing
- review of patient's clinical observations and biochemical markers
- evaluation of the transport characteristics of the patient's peritoneal membrane
- patient's residual renal function
- patient history of compliance with their prescribed PD regimen

(Kallenbach, 2016; Daugirdas *et al.* 2015; Levey, *et al.* 2016 & Thomas, 2014; Nissen, *et al.* 2017)

The efficiency of PD depends upon the transport characteristics, of the patient's peritoneal membrane, for solute clearance and ultrafiltration. Therefore determining these characteristics via dialysis tests enables the most effective PD modality selection for the patient e.g.: APD with shorter dwell times vs CAPD with longer dwell times and gives guidance for selection of dialysis fluid strengths and volumes. The most common forms of adequacy testing are as follows:

1. PET: (Peritoneal Equilibrium Test) is a standardized test of peritoneal membrane permeability used to measure the rate of solute removal, glucose absorption and net ultrafiltration in individual patients. The PET is used to classify the patients' peritoneal membrane transport characteristics. The peritoneal membrane transport classifications are: high (H), high average (HA), low average (LA), and Low (L). This information assists in determining

the most appropriate PD modality and individualizing the PD treatment regimen for the patient, it does not test adequacy.

(Kallenbach, 2016; Levey, *et al.* 2016)

2. 24 hr collection of urine (to determine residual renal function) and PD effluent (to determine dialysis clearance) are needed at regular intervals to determine if dialysis adequacy targets are being met. This is often referred to as the 24hr adequacy test and it can be combined with the PET.

These collections are analysed for urea and creatinine and the result expressed as below:

- Kt/V - a formula used to calculate the total clearance of urea from the patient's body via both the dialysis effluent and the urine. Where: K = Urea Clearance; t = Time; V = Volume of body water in which urea is distributed.
- Creatinine Clearance - is a calculation measuring removal of creatinine from the patient's body via both the dialysis effluent and the urine, corrected to a body surface area of 1.73 m^2. Results are expressed in a weekly litre volume.

Guidelines for PD adequacy targets have been made by several organisations with current agreement on a value for Kt/V > 1.7 / week and varying slightly for creatinine clearance with recommendations being > 50L/week/1.73 m^2 minimum.
(Kallenbach, 2016; Levey, *et al.* 2016; Thomas, 2014; Nissen, *et al.* 2017)

More information on Guidelines for Adequacy targets and patient management can be found in the Additional resources list at the end of this package.

GUIDELINES

Locate the HNELHD Guidelines and Procedures.

4. Renal: Peritoneal Equilibration Test (PET) and 24 hour Adequacy Test.

LEARNING ACTIVITY

9. What method of adequacy testing is performed in your facility? Who performs the test? How is the test performed?

10. What information for patient preparation for PET / adequacy testing should be provided and what changes are needed if the patient is using Icodextrin dialysis solution?

PHARMACOLOGY and PD

Drug Transport

Patients with ESKD are often on multiple medications which require dose adjustments due to many drugs and their metabolites being finally excreted from the body through the kidneys. As ESKD progresses both pharmacokinetics (the absorption, metabolism and elimination) and pharmacodynamics (the effect) of drugs in the patient can be altered. Added to this is the varying degree that drugs are cleared from the body via PD. Drugs that have low molecular weight, low volume of distribution and poorly bind to protein, are more easily transported across the peritoneal membrane. Renally excreted drugs and metabolites that are not well cleared by dialysis can accumulate and cause toxicity. (Levey, *et al.* 2016; Thomas, 2014)

Conversely systemically administered drugs can also have an effect on peritoneal dialysis especially those that alter the perfusion of the peritoneal capillaries (e.g. Vasodilators). Adequacy clearances in PD can be increased by improving the blood flow to the peritoneal membrane capillaries or decreased by drugs that reduce the abdominal blood flow. (Levey, *et al.* 2016; Heaf, 2012)

Certain medications can be added to the dialysis solution and administered via the - intraperitoneal route. If this route is used then medications must be added into the dialysis solution bag just prior to use. Strict aseptic technique must be followed when adding any medications to the dialysis solution bag and the dialysis solution bags labelled after medication addition.

Medications that can be Administered Intraperitoneally include:

Insulin: Insulin used to control blood sugar levels in diabetic patients can be administered via the intraperitoneal route. It is thought that this provides a more physiologic route of insulin supply to the liver via the portal vein however it is not a common practise due to the potential disadvantages and patient selection factors (dexterity, eyesight, need for extra blood sugar monitoring and ability of performing a different injection technique). Disadvantages of intraperitoneal insulin include potential contamination of dialysis solution during the injection procedure, need for increased insulin dose (due to insulin binding to the plastic solution bag and tubing and incomplete insulin absorption across the peritoneal membrane during dwell time) and risk of peritoneal and hepatic disorders. (Nissen, *et al.* 2017; Levey, *et al.* 2016; Daugirdas, *et al.* 2015)

Heparin: Heparin can be added to dialysis solution as a prophylactic measure to reduce the development of fibrin. Fibrin strands are a protein formation from fibrinogen (which is normally used in the blood clotting process) that can occur when inflammatory processes (such as infection) affect the peritoneum. The fibrin strands can clump together in the peritoneal fluid and cause PD catheter obstruction. Heparin is added to the dialysis solution before administration to the patient at a rate of 500 – 1000units/L. Intraperitoneal

heparin does not normally contribute to systemic anticoagulation. (Nissen, *et al.* 2017; Levey, *et al.* 2016; Daugirdas, *et al.* 2015; Thomas 2014)

Antibiotics: Intraperitoneal administration of antibiotics for the treatment of PD related peritonitis (infection of the peritoneal membrane) in general is superior to intravenous dosing. Intraperitoneal antibiotics can be given as continuous dosing (every dialysis solution bag) or intermittent (once per day). When using a daily dosing regimen the antibiotic containing dialysis solution must dwell for a minimum of 6 hrs to allow systemic absorption. Peritonitis will be discussed in a later section.

GUIDELINES

5. HNE Guideline and Procedure. Renal: Management of Peritoneal Dialysis Related Peritonitis http://intranet.hne.health.nsw.gov.au/__data/assets/pdf_file/0008/76049/HNELHD_GandP_14_21_Peritoneal_Dialysis_Related_to_Peritonitis.pdf

HOME DIALYSIS TRAINING AND GENERAL PD PATIENT CARE

Dialysis should be prescribed according to each individual patient's clinical and lifestyle needs. Dialysis at home allows patients to have more control of their treatment, more flexibility and reduce disruptions to their lifestyle. "The aim of a home dialysis training program is to educate patients to a standard whereby they can confidently care for themselves and perform PD in the community. " (Thomas 2014, p 243). Topics covered during a patients training program include:
How PD works, Types of PD, Hygiene, Dialysis Procedures, Performing clinical observations, Fluid balance, Medications, Exercise, Diet, Fertility and sex life, Dialysis problem solving, Planning for emergencies, Ordering and storing PD supplies and holidays and travel.

Patient non-adherence / non-compliance with their PD therapy or self-care management, contributes to hospital admissions and poor health outcomes. It is therefore important for nursing staff to be aware of the information given to patients during training so that key self-care practises can be reinforced with patients and ongoing consistent education can be provided to patients. This, along with regular monitoring of patients and adequacy of their therapy, provision of support services and appropriate interventions, help to optimise the patients long term outcomes.
(Kallenbach, 2016; Levey, *et al.* 2016; Thomas, 2014)

Self-care / Patient care Practises

Infection Control

Due to their impaired immune response (including reduced B cell, T cell and phagocytosis) dialysis patients are at increased risk and have increased incidence of infections. (Nissen,

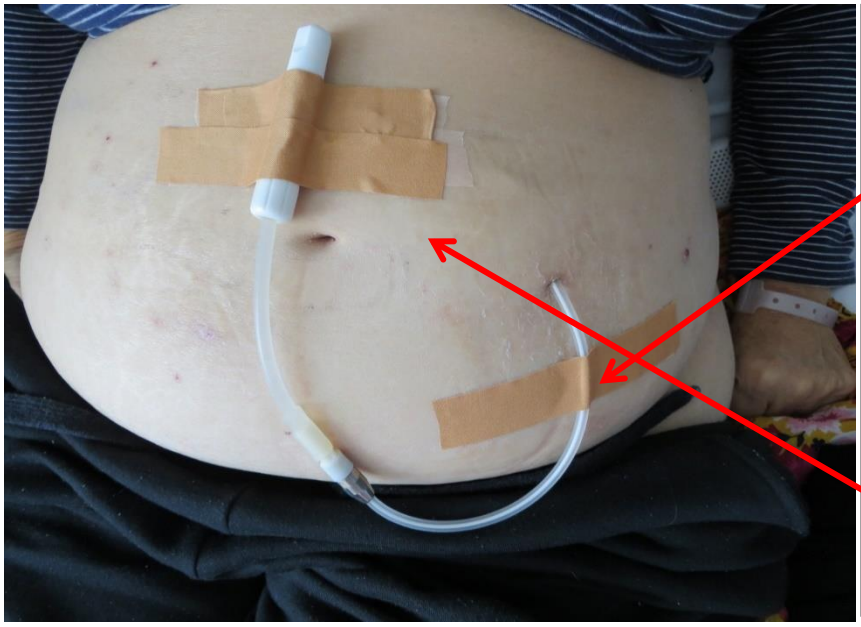
et al. 2017). The peritoneal dialysis catheter provides a direct and indirect route entry into the peritoneum and dialysate solution provides a growth medium for microorganisms. Much information and practise is provided to patients during training to ensure they understand the importance of cleanliness, sources of germs, how to prevent germs spreading, correct technique to perform exit site care, what to do if contamination occurs during a dialysis procedure or they experience signs and symptoms of an infection. (Wansey Dialysis Centre, 2016). Nursing staff can demonstrate and reinforce this information and best practises by following strict aseptic technique, hand hygiene and infection control practises, and correct procedure steps when caring for PD patients.

PD Catheter Exit Site Care

The PD catheter is the PD patient's lifeline. The goals during initial care of the PD catheter exit site are to: stabilise the catheter (helps healing, reduces risk of early infection and promotes a tight skin seal around the PD catheter), promote healing, and prevent infection. The goals for chronic PD catheter exit site care are maintaining intact skin and catheter function and preventing infection. PD exit site care can vary with individual patients but a key requirement for all patients is that the PD catheter is securely anchored in correct alignment at all times.

The general care routine involves daily inspection and cleansing of the PD catheter exit site, application of a prophylactic topical antimicrobial medication (e.g. Medicated honey or Mupirocin if indicated) and covering with a dressing. Due to the high risk of contamination and subsequent infection, the patient's PD catheter exit site should not be immersed in water (bath, spa, swimming) without a protective water proof covering. (Nissen, *et al.* 2017; Kallenbach, 2016; Levey, *et al.* 2016; Daugirdas *et al.* 2015). See Figure 21 and the following extract from the HNELHD patient instructions for routine daily exit site care Preparation for Shower:

Figure 21 This is how a patient PD exit site should look before a shower if non water proof dressings are routinely used by the patient.



<u>Activity before showering</u>:

1. Remove old dressing, any outside tapes and gauze.
2. Ensure the anchor tape closest to your PD catheter exit site is holding the catheter securely in place – if the tape is not secure, replace this tape before you continue
3. Loop the rest of the catheter and ensure the tape holding the blue minicap end of your extension line is also secure – this end should be facing "Up" to prevent shower water from collecting in the connections

Picture source: HNELHD Tamworth Renal Outreach – teaching resources

Once the patient has completed their shower, the PD catheter anchor tapes are replaced and the PD catheter exit site dressing attended.

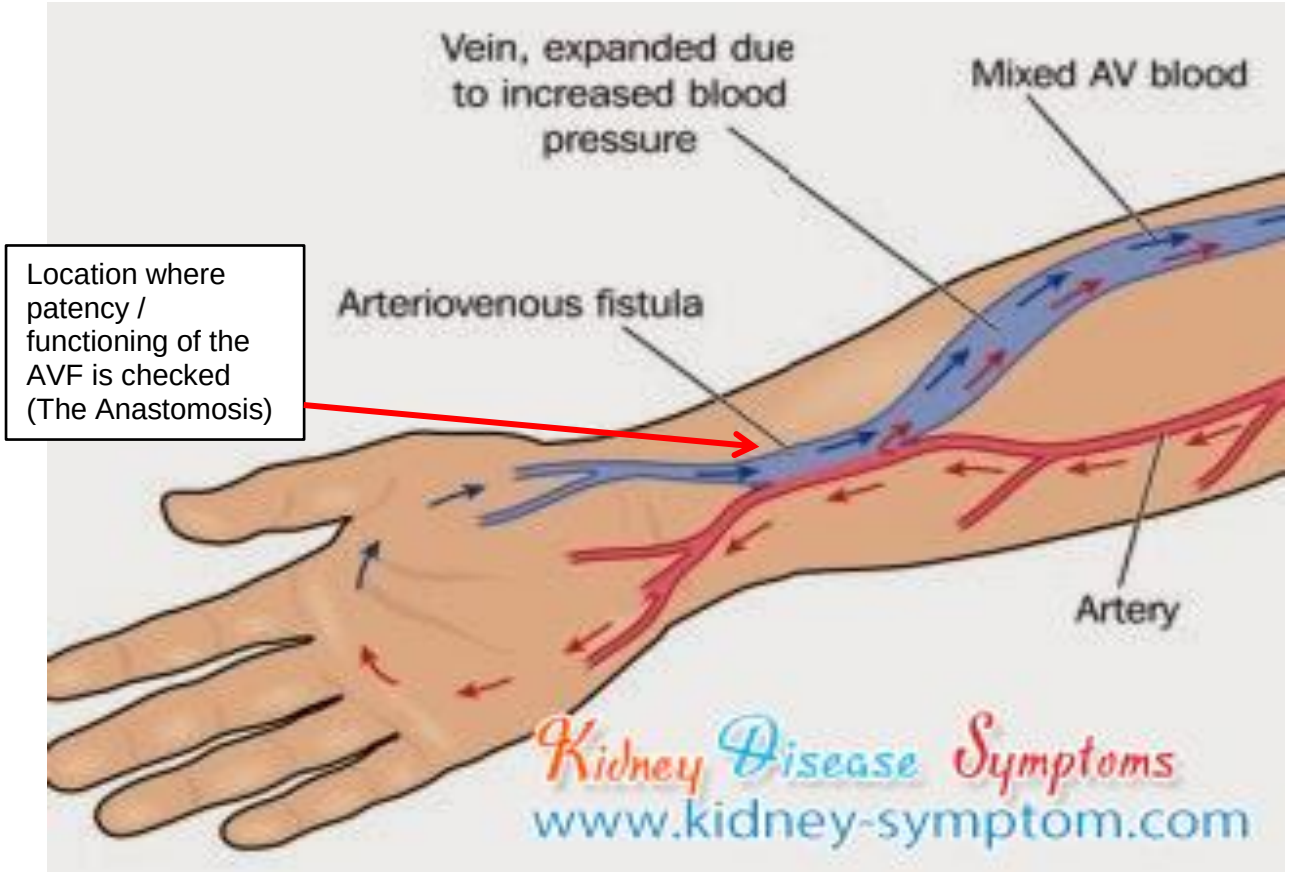
Vascular access

Vascular access is the Haemodialysis patient's lifeline and can be created in patients on PD as a "back up" should PD problems occur. If a patient develops complications from PD where PD therapy is no longer viable or the patient needs a temporary cessation of PD therapy to treat the complication then the patient's vascular access is used to provide haemodialysis (HD).

Creation of permanent vascular access for HD is via a surgical procedure to form an arteriovenous fistula (AVF) or arteriovenous graft (AVG).

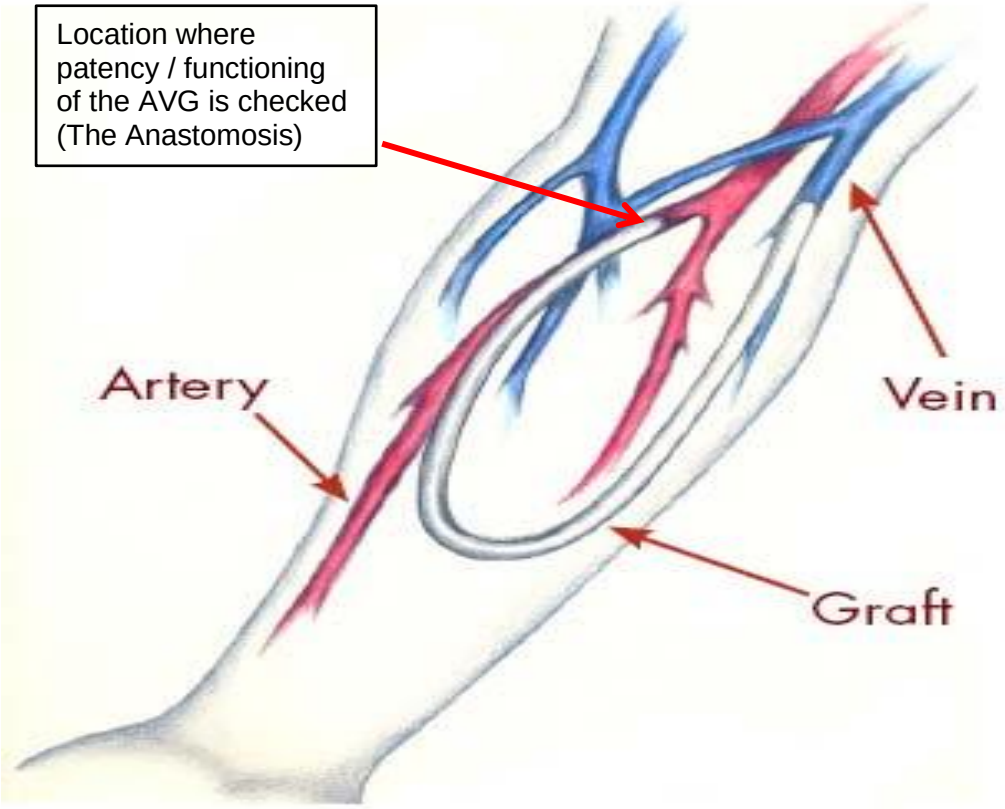
An AVF involves making a subcutaneous anastomosis (fistula) between an artery and a vein allowing arterial blood flow directly into the vein (see Figure 22 below). This increased blood flow causes dilation and thickening of the vein's walls (arterialisation) providing a suitable portal for dialysis cannulas to be inserted for HD. An AVF can be created in several sites but preferred placement is in the patient's non dominant forearm.

Figure 22: Diagram of AVF placed near the wrist between the radial artery and cephalic vein.



An AVG is similar to the AVF except that the connection between the feeding artery and vein is made by a tube (graft) of artificial material (which is usually made of polytetrafluoroethylene PTFE polymer). See Figure 23.

Figure 23: Diagram of graft between brachial artery and cephalic vein.



Picture source: https://www.kidney.org/patients/peers/dialysis

Continued functioning / patency of the fistula or graft should be checked at least daily by palpating over the anastomosis (feeling for the Thrill) and auscultation (listening for the Bruit) over the anastomosis.
The thrill of an AV access is a vibration or "buzzing" sensation that can be felt and the bruit is a "swooshing pulsing" noise heard on auscultation. Both the thrill and bruit arise from the turbulence caused by atrial blood flow entering the vein at the anastomosis site (see Figures 22 and 23) and a change in these can indicate stenosis or clotting of the vessel. (Levey, *et al.* 2016; Daugirdas *et al.* 2015)

Nutrition

The peritoneal dialysis patient has special dietary needs that vary from the haemodialysis patient. The PD patient has the benefit of a more continuous dialysis therapy so can have a less restricted diet than the HD patient but the PD patient loses a substantial amount of protein through the peritoneal membrane during dialysis.
Numerous factors associated with ESKD (including inadequate nutrient intake, increased catabolism, increased nutrient losses during dialysis and inadequate dialysis) contribute to the risk of patients developing protein-energy malnutrition and a specific syndrome PEW (protein energy wasting).

Malnourished patients have a higher incidence of morbidity and mortality, with changes in serum albumin levels over time being associated with better or worse patient survival. A key component to patient care involves comprehensive nutritional assessment and individualised dietary counselling. Patients should receive information that both promotes specific dietary intake to meet protein and energy goals and encourages appropriate restrictions of phosphate and oral fluid intake. (Nissen, *et al.* 2017; Daugirdas *et al.* 2015)

READING

3. Read the sections (listed below) in the Wansey Dialysis Centre – Training manual for Peritoneal Dialysis – HNELHD – 2016.

Topic sections:

- Importance of cleanliness and handwashing
- Catheter exit site care
- Exit site dressing instructions
- Catheter exit site or Tunnel infection
- Care of a new AV fistula
- Observations needed for your treatment
- Fluid Balance
- Medication on PD

LEARNING ACTIVITY

From your reading - Answer the Questions below:

11. How is the importance of "cleanliness" demonstrated when nursing staff are performing patient care in a health facility? - give examples.
12. What may cause a fistula to clot and what precautions should be taken to prevent clotting?
13. What physical issue may change in Blood pressure indicate? (increase and decrease)
14. What body temperature reading should trigger concern?
15. How often should patients weigh themselves at home?
16. What is a target weight and when should this be adjusted?
17. What dialysis solution strength should be used if dehydration is suspected?
18. When should phosphate binders be taken?
19. Why is preventing constipation important?

	OPTIONAL ACTIVITY Locate your facilities, renal dietician and identify what general diet / fluid information is provided to PD patients.

General patient care

Part of treatment/care management practises for ESKD patients is preventing or minimising the impact of numerous systemic complications that can affect ESKD patients.

These include,

- Anaemia management – correcting anaemia by administration of Erythrocyte-stimulating agents and iron supplementation
- Prevention of cardiovascular complications – by promoting good blood pressure control and normal body fluid balance status, management of hyperlipidaemia & hyperglycaemia.
- Bone disease – reducing impact of abnormalities of calcium, phosphorous, Parathyroid hormone and vitamin D metabolism (e.g. Hyperphosphataemia , Hyper/ Hypocalcaemia) – By diet phosphate restriction, medications (including phosphate binders, Vitamin D), adjusting dialysate calcium levels and possible Parathyroid reduction interventions.
- Interventions to manage disorders of Nutritional status. Note: Patients are at risk of electrolyte abnormalities especially those related to potassium, magnesium and sodium.

Hyperkalaemia generally results from excessive dietary intake and insufficient dialysis. Hypokalaemia is usually due to poor nutritional intake; excessive losses, either through vomiting or diarrhoea or excessive dialysate losses. The most common symptoms for both include mild or severe muscle weakness and cardiac arrhythmias. So monitoring patient's oral intake especially during illness is important. (Nissen, et al. 2017; Daugirdas et al. 2015; Thomas 2014; advancedrenaleducation.com 2016)

COMPLICATIONS OF PERITONEAL DIALYSIS

Complications of peritoneal dialysis can be divided into two main groups, non-infectious and infectious. Non-infectious complications include mechanical issues relating to the PD catheter (e.g. inflow, outflow obstruction), the process of PD (e.g. changes to the function of the peritoneal membrane) and medical issues (e.g. cardiovascular complications). Infectious complications are predominantly peritonitis and catheter related (both exit site and tunnel).

INFECTIOUS COMPLICATIONS OF PERITONEAL DIALYSIS

Peritonitis is an infection of the peritoneal cavity caused by entry of microorganisms into the usually sterile cavity. The two major routes for micro-organisms to enter the peritoneum are:

- External - via contamination during the dialysis procedure or infection tracking from the PD catheter exit site (Intraluminal & Periluminal).
- Internal - via the bowel, blood stream or rarely ascending through the vagina and fallopian tubes (Transmural, Haematogenous & Vaginal).
- Following surgical or traumatic perforation.

Peritonitis is the major complication of peritoneal dialysis and "is the direct or major contributing cause of death in around 16% of patients a potentially life threatening condition" (Kam-Tao, Szeto, Piraino, Arteaga, Fan, Figueiredo, Fish, Goffin, Kim, Salzer, Struijk, Teitelbaum & Johnson, 2016, p 481).
Peritonitis can lead to PD catheter removal, damage to the peritoneal membrane resulting in loss of adequate membrane clearance of solutes, formation of Adhesions and loss of PD as a therapy for the patient.

Peritonitis can be classified into several categories (ISPD Guideline):

- *Infectious Peritonitis* - related to micro-organisms.
- *Refractory or resistant Peritonitis* - symptoms do not improve within 48 hours of appropriate treatment.
- *Relapsing Peritonitis* - reappearance of symptoms after initial improvement.
- *Recurrent Peritonitis* - the recurrence or peritonitis with the same organism within 2 weeks of the completion of therapy, the organism and sensitivities must be identical.
- *Reinfection/New Infection* - a new episode after more than 4 weeks after treatment completed with the same or different organism.

The severity of an episode of peritonitis depends upon the causative organism and can influence the clinical signs and severity of symptoms patients' experience. The common clinical signs and symptoms of peritonitis are:

- Abdominal pain
- Cloudy PD effluent
- Fever
- Nausea / vomiting / diarrhoea

ALERT: The appearance of PD effluent is variable in colour but should be clear. If clarity of the PD effluent is uncertain a plain text document can be placed underneath the "clear viewing area" on the drain bag, and the writing should be clearly visible through the PD effluent solution. Slight cloudiness of PD effluent can be distinguished this way and always checked this way if there is any doubt. Figure 24 demonstrates clear PD effluent showing

the visibility check through the “clear viewing area” on the drain bag. Figure 25 shows the contrast with heavily cloudy PD effluent.

Figure 24: Clear PD effluent

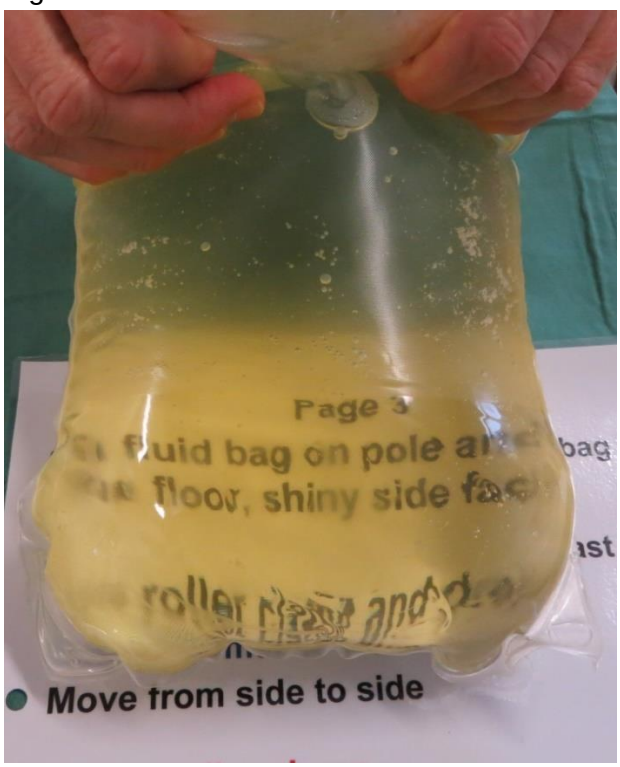


Figure 25: Cloudy PD effluent

Picture source: HNELHD Tamworth Renal Outreach– teaching resources

Diagnosis is made by testing of the dialysate effluent for cell count, gram stain and microbial culture. However PD patients presenting with cloudy effluent are presumed to have peritonitis and should have intra peritoneal empiric antibiotic therapy initiated as soon as possible. A further recommendation is to commence all PD patients undergoing antibiotic therapy on fungal prophylaxis treatment.

ALERT: PD patients undergoing any antibiotic therapy are at an increased risk of developing fungal peritonitis.

Subsequent antibiotic therapy may need to be adjusted according to microbial culture and sensitivity results. Some patients may require the addition of heparin to the dialysis solution if large fibrin clots are present.

Peritonitis impacts the function of the peritoneal membrane, increasing the permeability to water, glucose and protein, leading to special considerations for patient management and dialysis prescription:

- Increased glucose absorption from the dialysis solution will reduce the amount of ultrafiltration per PD exchange and expose the patient to fluid overload if dialysis prescription is not appropriately modified (e.g. - higher glucose strength dialysate and shorter dwell times).
- Infection and change in glucose absorption from dialysate will impact diabetic patient's glycaemic control. Blood sugar monitoring and appropriate insulin dosing adjustments will be required.
- Increased peritoneal protein loss (and possible gastric symptoms) can compromise patient's nutritional status and may require dietary intervention and nutritional supplements.

A main goal in successful PD is preventing peritonitis. Strategies for this include:

- Appropriate patient selection for therapy.
- Quality individualised patient education and training.
- Patients having good bowel management and avoiding constipation.
- Performing good PD catheter exit site care and use of topical antimicrobial medications on the exit site.
- Ensuring that PD exchanges are performed by skilled personnel when patients are in a health facility care.
- Providing ongoing support services and review of patients to identify mental/physical health changes that may compromise the patient's ability to continue to self-care.

It is vital to re-evaluate patient skills post peritonitis to determine aetiology of contamination/infection and provide retraining if issues with patient technique are identified (Kallenbach, 2016; Levey, *et al.* 2016; Daugirdas *et al.* 2015; Nissen, *et al*. 2017; Thomas 2014; Kam-Tao, *et.al.* 2016).

GUIDELINES

6. HNE Guideline and Procedure. Renal: Management of Peritoneal Dialysis Related Peritonitis http://intranet.hne.health.nsw.gov.au/__data/assets/pdf_file/0008/76049/HNELHD_GandP_14_21_Peritoneal_Dialysis_Related_to_Peritonitis.pdf

LEARNING ACTIVITY

20. Identify three empirical antibiotics suggested in the above guideline for peritonitis treatment.

21. How long must PD fluid remain indwelling if antibiotics are administered intermittently?

22. What medication and dose is used for fungal peritonitis prophylaxis?

Exit Site Infection is the inflammation of the Tenckhoff catheter exit site with purulent discharge. Positive culture in the absence of inflammation does not indicate infection. Risk

Factors for exit site infection include: dialysate leak; bleeding or haematoma; early colonization; delayed or ineffective exit site healing; excessive manipulation of the catheter; inadequate anchoring of the catheter; trauma - hard pull or excessive twisting of catheter or external pressure from tight clothing/belts; cuff extrusion; staph aureus nasal carrier; wet exit site- excessive perspiration or submersion; and skin breakdown. The signs and symptoms of an exit site infection are bright pink or red discoloration around exit site (>13mm border to border), swelling, pain, tenderness, drainage (purulent or bloody), or exuberant granulation tissue or proud flesh around the exit site and/or in the visible sinus. A culture swab of the exit site needs to be taken. See Figures 26 and 27, below for comparison of a perfect exit site and acute infection.

Figure 26: Perfect PD catheter exit site

Picture Source: advancedrenaleducation.com

Figure 27: Acutely infected PD catheter exit site

See http://advancedrenaleducation.com/content/classifying-exit-sites-and-diagnosing-exit-site-infections – for classification of Acute and Chronic exit site infections.

Tunnel Infection is the infection of the subcutaneous tunnel between the exit site and the peritoneum. Usually occurs as a result of peritonitis or exit site infection. A tunnel infection is poorly treated with antibiotic therapy and usually the catheter needs to be removed. Signs and symptoms include: redness along tunnel; purulent discharge; pain/tenderness along tunnel; catheter fits loosely in tunnel; abscess over the catheter tunnel; irregularity, thickening along subcutaneous tunnel. It is not uncommon to have a simultaneous exit site infection or peritonitis. Patients are at risk of a tunnel infection if: catheter was contaminated during insertion; delayed wound healing; severe trauma; exit site infection or peritonitis; dialysate leak; or cuff extrusion.
(Kallenbach, 2016; Levey, *et al.* 2016; Daugirdas *et al.* 2015 Nissen, *et al.* 2017; advancedrenaleducation.com 2016)

More information on patient management of Peritonitis and exit site infection can be found in the Additional resources list at the end of this package.

GUIDELINES

7. HNE Guideline and Procedure: Renal: Peritoneal Dialysis Catheter – Management of Exit Site or Tunnel Infection
http://intranet.hne.health.nsw.gov.au/__data/assets/pdf_file/0019/76051/HNELHD_GandP_14_22_Peritoneal_Dialysis_Catheter_Exit_Site_and_Tunnel_Infection.pdf

LEARNING ACTIVITY

23. List the signs and symptoms of an infected exit site

24. State what actions should be taken if an infection in the PD catheter exit site is suspected?

NON - INFECTIOUS COMPLICATIONS OF PERITONEAL DIALYSIS

Complications Associated with Increased Intra-abdominal Pressure

The instillation of PD fluid into the peritoneal cavity increases the intra-abdominal pressure proportionate to the volume of dialysis solution instilled. Body position during the dwell phase of a PD exchange also impacts pressure. The supine position provides least pressure and sitting the most. Activities such as coughing, sneezing, bending, lifting and being constipated also increase intra-abdominal pressure.
This increase is a risk factor for the following complications:

- Hernia formation – particularly susceptible patients are those with congenital or acquired defects of the abdomen or have undergone previous abdominal surgeries. Swelling may be visible and PD effluent drain volumes may be slow or reduced. Hernias pose a risk of strangulation or incarceration of bowel loops and potential peritonitis. Surgical repair is often indicated with a temporary suspension of PD therapy. See Figure 28, for an example of abdominal hernia.

Note: as previously discussed this is when the patient's vascular access for HD therapy will be used.

Figure 28: An abdominal hernia at the site of a prior abdominal incision. This hernia would need surgical repair before the patient could be considered for PD.

Source: Dr P. Marazzi/Science photo library

- Dialysate leak – this can be around the catheter tunnel or into subcutaneous tissue leading to, clear fluid leaking from the PD catheter exit site, decreased PD effluent drain volumes and patient weight gain without generalised oedema. Examination of the patient may reveal an asymmetry of the abdomen, oedema of the labia in females or the scrotum / penis in males. Management revolves around reducing dialysate fill volumes, commencing APD therapy in the supine position or temporary transfer from PD therapy if surgical intervention is required. See Figure 29, showing a subcutaneous dialysis fluid leak. Note the appearance is similar to a hernia.

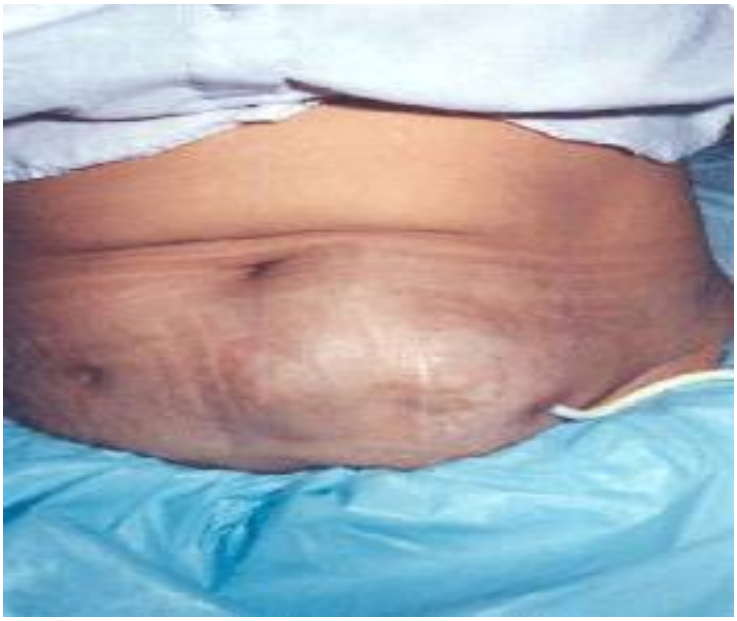


Figure 29: Subcutaneous dialysate fluid leak around the PD catheter –

Note: PD fluid leaks may not always appear so obvious.

Source: advancedrenaleducation.com

- Hydrothorax – Patients with a defect in the hemidiaphragm are at risk of dialysis fluid leaking into the plural cavity leading to a Plural effusion. The patient may

- experience mild to severe shortness of breath – worse after lying down and reduced PD effluent drain volumes. Management requires ceasing PD and possible pleurodesis. Patients may be able to resume PD if the intervention procedure is successful.
- Back pain - back pain is a common complaint among some patients undergoing PD. The presence of dialysate in the abdomen changes the body's centre of gravity increasing inward curvature of the spine (lordosis) especially in the presence of poor muscle tone. Management may involve back exercises, medication, trying smaller dialysate volumes or ADP therapy at night with no day fill. Causes of low back pain unrelated to dialysis should be investigated. The patient may require transfer to HD.

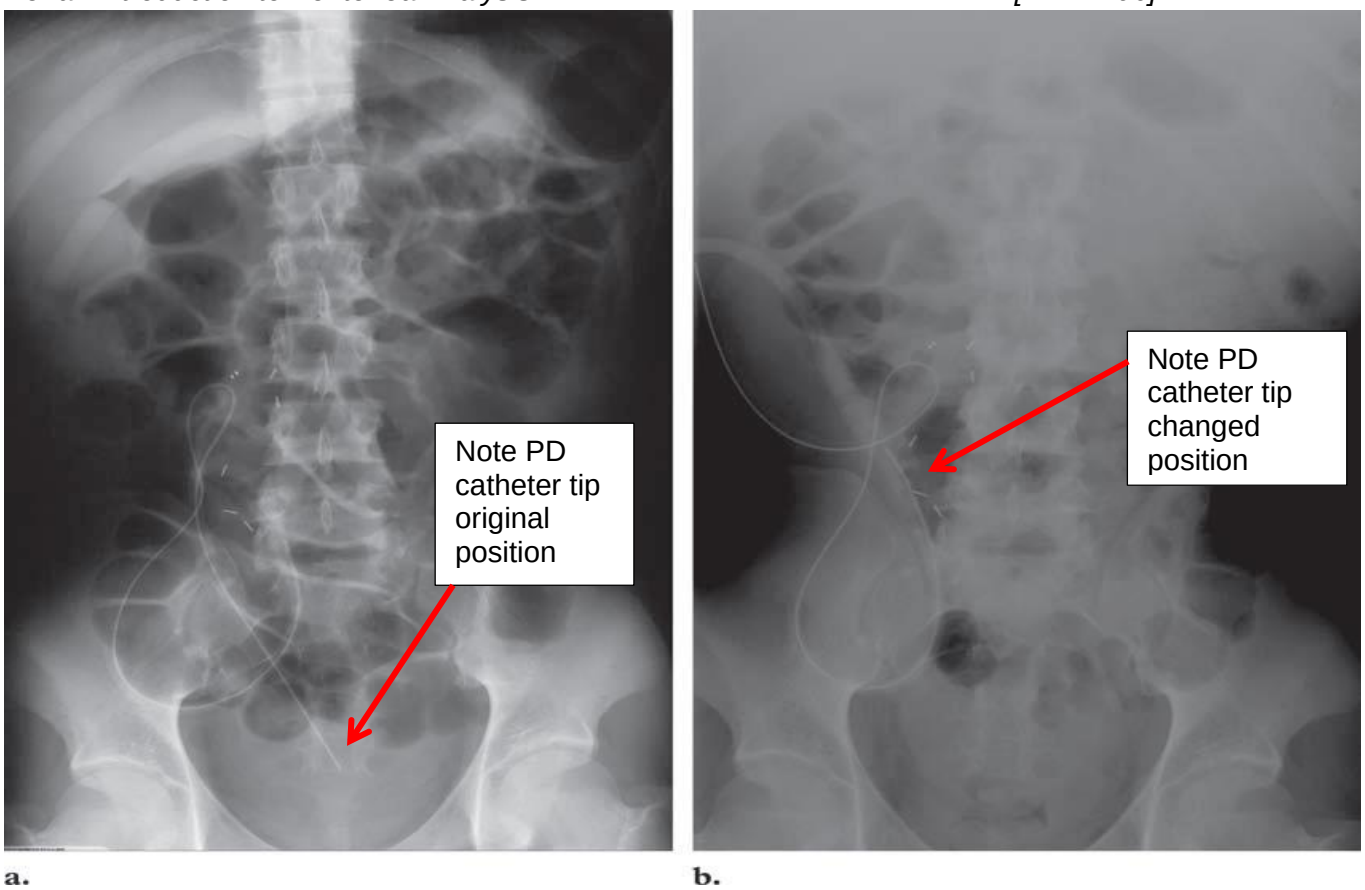
Other complications relating to increased intra-abdominal pressure include: Uterine prolapse (this can sometimes be managed by insertion of a ring pessary but may require hysterectomy), haemorrhoids and vagal stimulation leading to bradycardia, gastro intestinal disorders, chronic sleep disturbance and sleep apnoea.
(Kallenbach, 2016; Levey, *et al.* 2016; Daugirdas *et al.* 2015 Nissen, *et al*. 2017; advancedrenaleducation.com 2016; Thomas, 2014)

Mechanical Complications Associated with PD catheter Function
Early complications associated with PD catheters are usually related to the catheter insertion procedure and include: perforation or injury to internal blood vessels, abdominal wall, internal organs (especially bladder or bowel; infection, pain, haemorrhage and dialysate fluid flow problems when PD is commenced).
Later complications associated with PD catheters include:

- Dialysate Inflow / Outflow problems – caused by; obstruction of the catheter with fibrin, omental wrapping, intestinal trapping; migration of the internal PD catheter end out of pelvis; catheter kinks or entrapment due to internal adhesions; entrapment of dialysate in the abdominal cavity due to adhesions and constipation. See Figure 30, illustrating catheter migration leading to effluent outflow problems.

Figure 30:

a. Abdominal radiograph shows the correct position of a CAPD catheter, with the tip in the pelvis. The surgical clips are from a previous failed renal transplant.
b. Abdominal radiograph obtained in the same patient 4 weeks later shows malposition of the CAPD catheter tip in the right flank.



Source: RG ■ Volume 29 • Number 2 Stuart et al - March-April 2009 *radiographics.rsnajnls.org*

Interventions include, irrigation of the catheter, Intraperitoneal Heparin administration, repositioning the catheter, administering regular aperient medication to manage constipation, replacement or permanent catheter removal.

- Infusion pain – can markedly vary in intensity and risk. It can be associated with new patients initiating dialysis (stretching of the intraperitoneal structures), peritonitis and other inflammatory processes of the peritoneum, acidic pH of the dialysate, and temperatures of dialysis solution, hypertonicity of the solution, rapid infusion rates and from stretching of the intraperitoneal structures especially in the case of compartmentalization of PD fluid due to adhesions. Constipation is another possible cause that can lead to infusion pain – especially if the catheter tip becomes entrapped in sensitive abdominal area as PD fluid is drained in or out of the abdomen. Treatment of infusion pain is dictated by the specific cause (e.g. less acid PD solutions may be used, ensuring PD fluid is body temperature before infusion) but often just reducing the infusion rate of PD fluid may alleviate the pain.

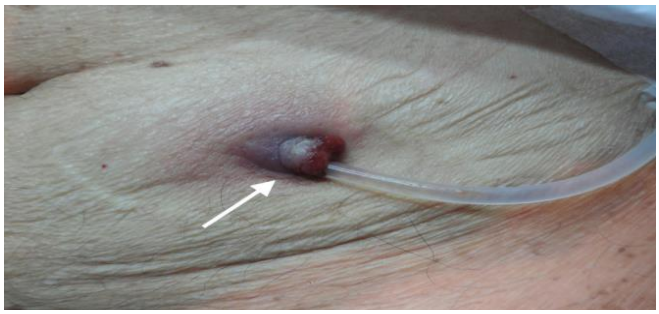
- Drain pain – this is more common and often referred to as “catheter tip pain”. As PD effluent is siphoned out of the abdomen the internal catheter tip can come into contact with sensitive areas of the peritoneum or internal structures causing pain. This is aggravated by constipation (causes crowding of the bowel around the internal catheter). Management includes resolving constipation, having the patient change body position during the PD drain phase or not completely draining the PD effluent from the abdomen.

For persistent infusion / drain pain caused by internal PD catheter position relocation / repositioning of the PD catheter may be necessary.

- Shoulder pain – this is usually associated with accidental infusion of air into the peritoneum (due to loose dialysis equipment connection or poor procedure technique) which lodges under the diaphragm. Rarely, free gas in the peritoneum is a symptom of bowel integrity issues and must be surgically managed. For accidental air infusion management may include: having the patient drain dialysate whilst in the Trendelenburg position, review of the patient's PD exchange procedure technique, ensuring that there is no break in patient catheter / extension line equipment. Often the patient has to wait until the air in the abdomen is absorbed and may require oral analgesia to manage the pain until this occurs.

- Subcutaneous Cuff extrusion through the exit site – this can result from positioning this cuff too close to the exit wound during insertion procedure, poor anchoring /dressing of the PD catheter allowing excessive movement and pressure on the external PD catheter, patient weight loss (reduction in subcutaneous tissue) and exit site infections. See Figure 31.

Figure 31: An extruded PD catheter cuff protrudes from the exit site (see arrow).



Picture source: B Hathaway (Endovascular Today - June 2017)

Management may involve shaving the extruded cuff from the catheter, treating infection and if not able to resolve infection PD catheter removal and replacement.

- Erosion of internal segment of PD catheter – this can result from poor positioning of the PD catheter subcutaneous segment during insertion procedure, poor anchoring /dressing of the PD catheter allowing excessive movement and pressure on the external PD catheter, external pressure over the internal PD catheter (e.g. clothing, belts, activities) patient weight loss (reduction in subcutaneous tissue) and tunnel infections. See figure 32.

Figure 32: Skin breakdown resulting from an antibiotic-resistant chronic tunnel infection. Part of the internal PD catheter has eroded through the skin.

Picture source: B Hathaway (Endovascular Today - June 2017)

Management involves treating infection, PD catheter removal and possible replacement after abdomen healed.
(Kallenbach, 2016; Levey, *et al.* 2016; Daugirdas *et al.* 2015 Nissen, et al. 2017; Hathaway, 2017; advancedrenaleducation.com 2016; Thomas, 2014)

GUIDELINES

8. HNE Guideline and Procedure: Renal: Management of Peritoneal Dialysis Catheter Extension Line Contamination
http://intranet.hne.health.nsw.gov.au/__data/assets/pdf_file/0003/69303/HNELHD_GandP_17_22_Extension_Line_Contamination.pdf

READING

4. Read the sections (listed below) in the Wansey Dialysis Centre – Training manual for Peritoneal Dialysis – HNELHD – 2016.

Topic sections: Problem solving -

- Contamination of Extension Line
- Disconnected Line at Titanium/Plastic Connector
- Split Extension Line
- Clean Fluid runs into drainage bag
- Leaking Drainage Bag
- Fluid not running out
- Fluid not running in
- Blood in Drainage Bag
- Peritoneal Leaks
- Constipation

LEARNING ACTIVITY

From your readings - Answer the Questions below:

25. What should you do if the end of the patient's PD catheter (extension line) is contaminated at the beginning of an exchange?

26. What should you do if end of the patient's PD catheter (extension line) is contaminated at the end of an exchange?

27. What should you do if the patient's PD effluent will not drain out?

28. What clinical signs, symptoms and findings may be present if the patient develops a PD fluid leak?

29. How can you assist a patient experiencing pain on inflow or drain out of PD fluid?

30. What care will assist in the prevention of a PD catheter cuff extrusion?

31. What major electrolyte disturbance is a PD patient at risk of, if they are unwell and cannot maintain sufficient oral nutrient intake?

Complications Associated with Peritoneal Membrane function and integrity

- Transport characteristics of the Peritoneal Membrane – generally over time there is a decline in the ultrafiltration ability of the membrane. Patients show good solute transport with poor Ultrafiltration and gradual need to increase the use of hypertonic solutions. Patients may have a more serious change with both decreased solute and ultrafiltration ability often associated with decreased peritoneal surface area from peritonitis or adhesions. This can be detected by repeating the PET (which monitors the functional ability of the peritoneal membrane, as discussed previously). Management can include adjustments to the patient's PD prescription and dialysate fluid type to transfer from PD as a therapy. Strategies to preserve PD membrane function include preventing exit site trauma & infections, peritonitis and reducing membrane exposure to high glucose load solutions (e.g.: 4.45%).

- Sclerosing Encapsulating Peritonitis – this may occur with length of time on dialysis and repeated episodes of peritonitis. The peritoneal membrane becomes thick and fibrous with layers that encapsulate the bowel to form many adhesions. Signs and symptoms include a decreased ultrafiltration ability, recurrent abdominal pain, nausea and vomiting, partial or complete bowel obstruction. Treatment may involve surgery to relieve bowel obstruction, removal of PD catheter and permanent transfer to HD.

- Haemoperitoneum – or blood in the peritoneal cavity occurs most commonly among premenopausal women but can occur from peritoneal blood vessel rupture (e.g. Patients straining to lift heavy objects, trauma), or intra-abdominal pathology (e.g. Pancreatitis, ruptured hepatic cysts). The presentation of haemoperitoneum can vary from a light-red contamination in the dialysate effluent, to the appearance of gross blood in the effluent bag. Management revolves around the cause of the bleeding and usually spontaneously resolves. If bleeding continues or is severe then further investigation and appropriate interventions are needed (Kallenbach, 2016; Levey, *et al.* 2016; Daugirdas *et al.* 2015 Nissen, et al. 2017; advancedrenaleducation.com 2016; Thomas, 2014).

More information on complications of PD, patient management and care of the PD patient can be found in the Additional resources list at the end of this package.

HNELHD staff can access support to care for PD patients by contacting John Hunter Hospital Renal Service or Tamworth Rural Referral Hospital, Renal Service.

Appendix 1:

Instructions to access Readings and Resources

- To obtain a copy of - Ellis, P. (2015) Understanding peritoneal analysis: an intrinsic part of safe patient care. *Journal of renal nursing* 7(4), 162 -166 contact

- HNELHD Library service – Services can be accessed via the HNE Intranet or contacted via email or phone. See the link below: http://www.hnehealthlibraries.com.au/325

- To obtain access to the Wansey Dialysis Centre – Training manual for Peritoneal dialysis – HNELHD – 2016 contact:

- Wansey Dialysis Centre – Home dialysis Training Unit - 02 49048800 – Ask for the Home Therapies Team Leader.
- Tamworth Renal Dialysis Service – 02 6767 7046 – Ask for Home Therapies Training Unit

- To obtain access to Renal Guidelines and procedures go to the HNE Intranet - Policies, Procedures & Guidelines directory and search "**renal**". See link below: http://ppg.hne.health.nsw.gov.au/

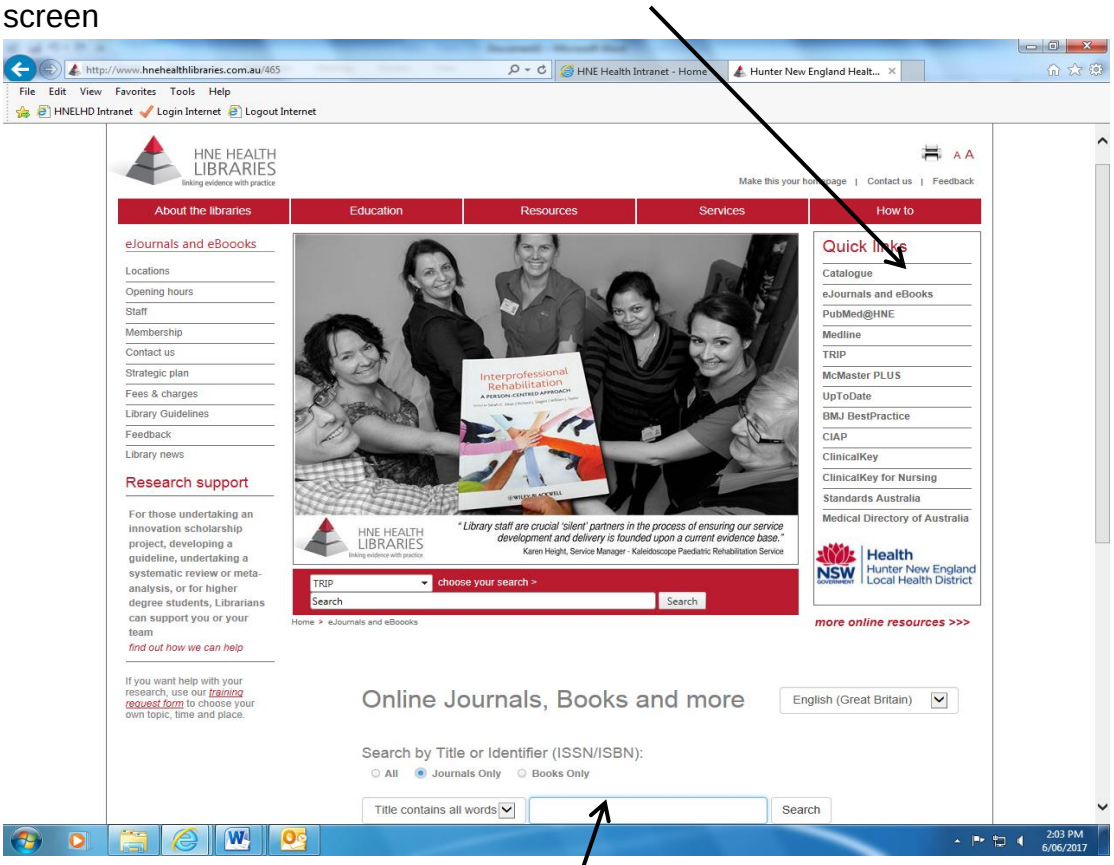
If you are having any issues with obtaining the readings / resources please contact the relevant Renal NE/CNC/CNE for assistance.

To search for additional resources (vial the HNE Intranet) - see following instructions:

Access to Online Journals

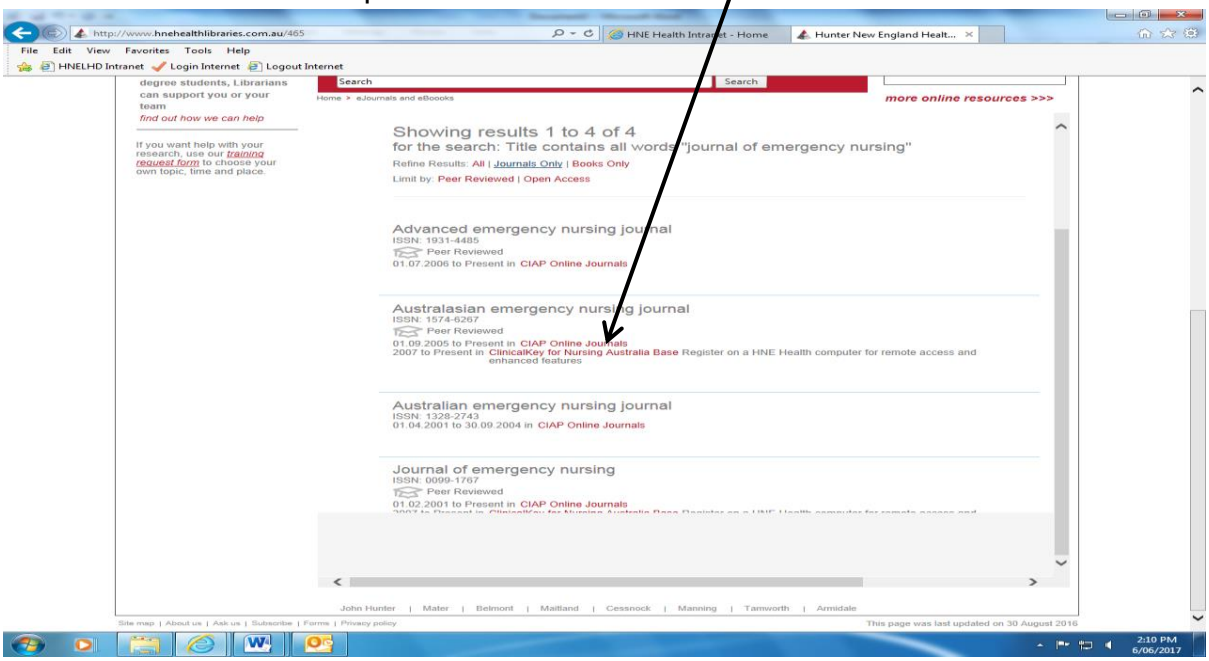
To locate a journal title:

- Go to the HNELHD Libraries homepage
- Click on eJournals and eBooks under Quick links on the right hand side of the screen

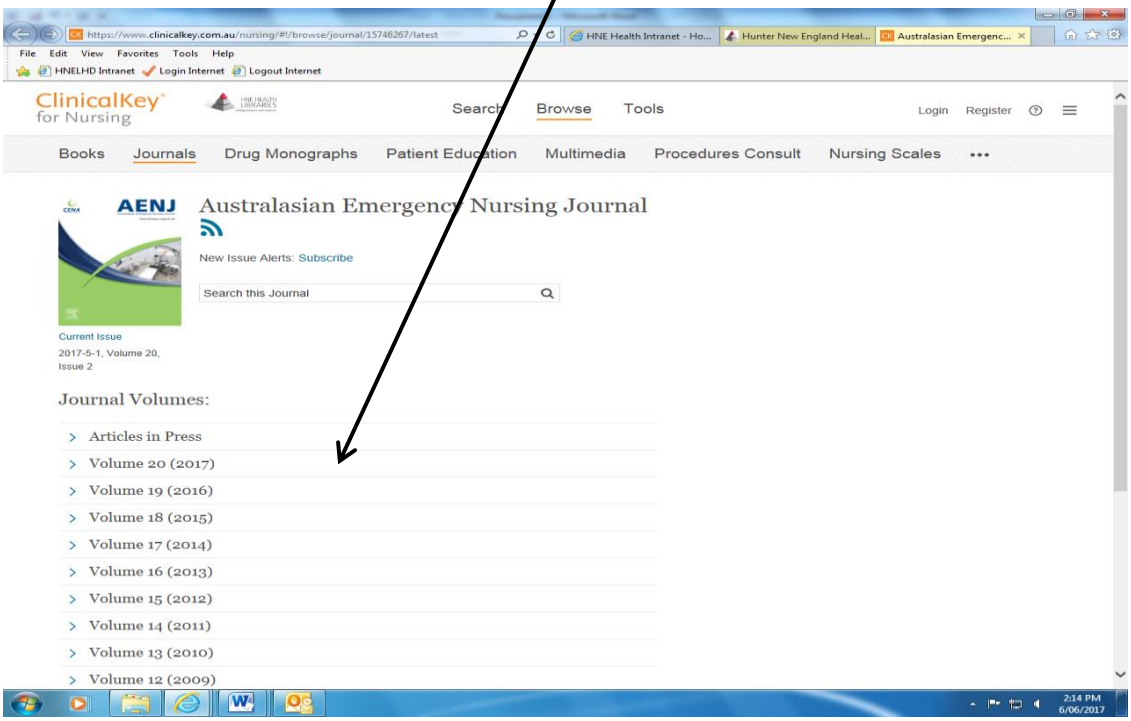


- In the box type in the name of the journal and click Search

- Scroll down to the title required and click on the red link



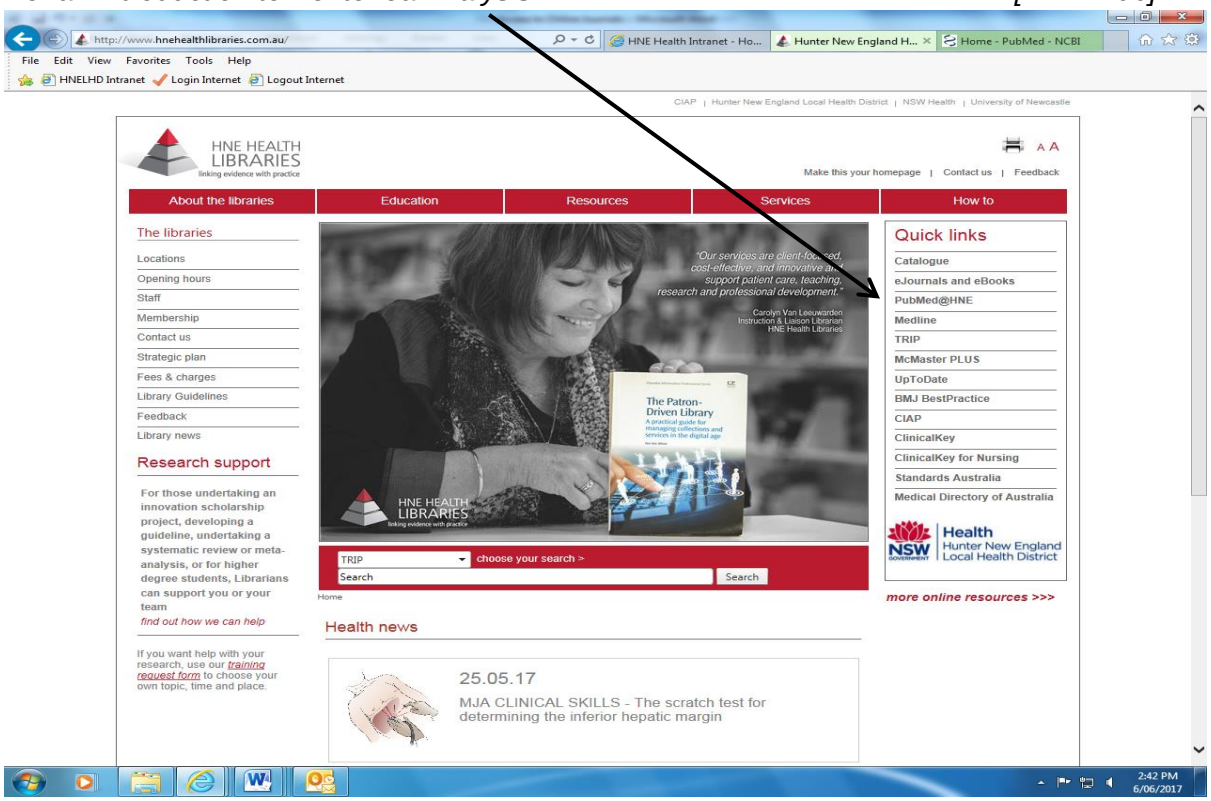
- When the journal appears, click on the volume and/or issue required



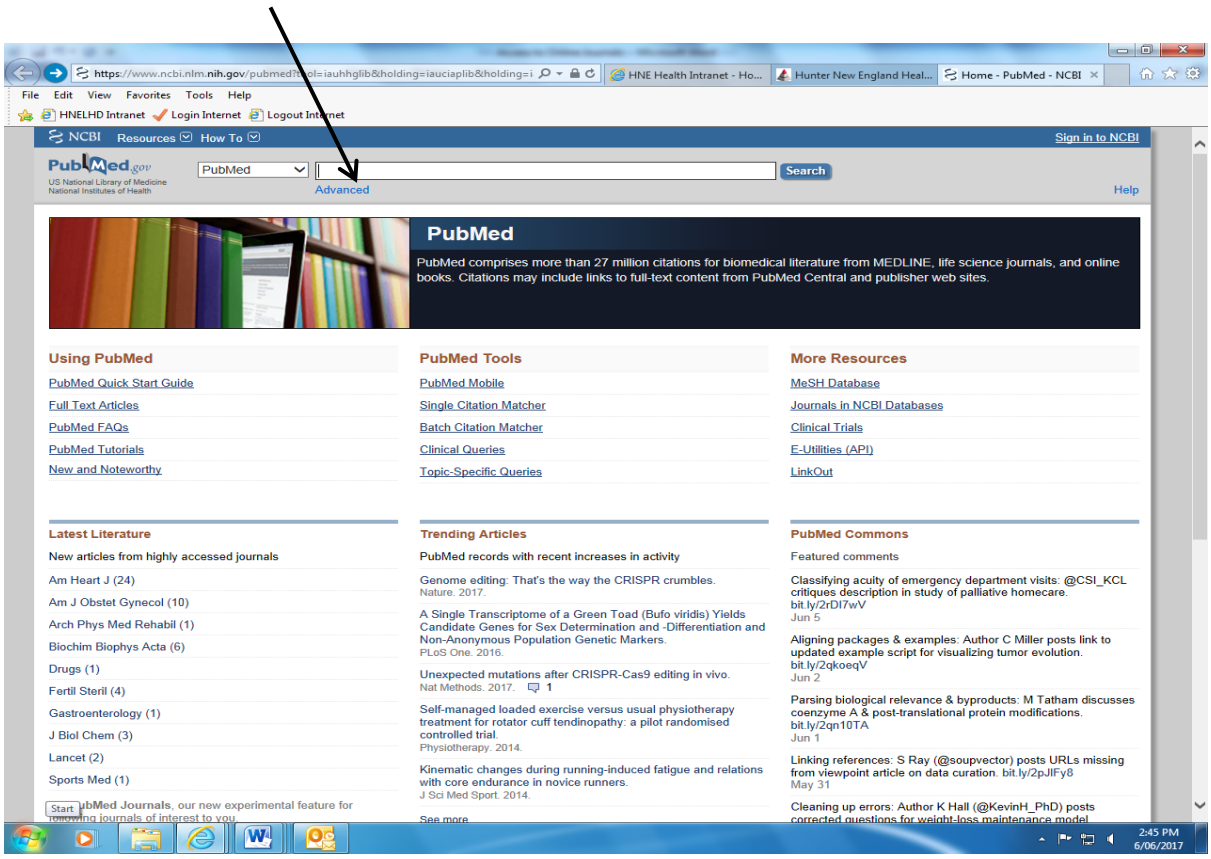
To locate a particular journal article:

- Go to the HNELHD Libraries homepage

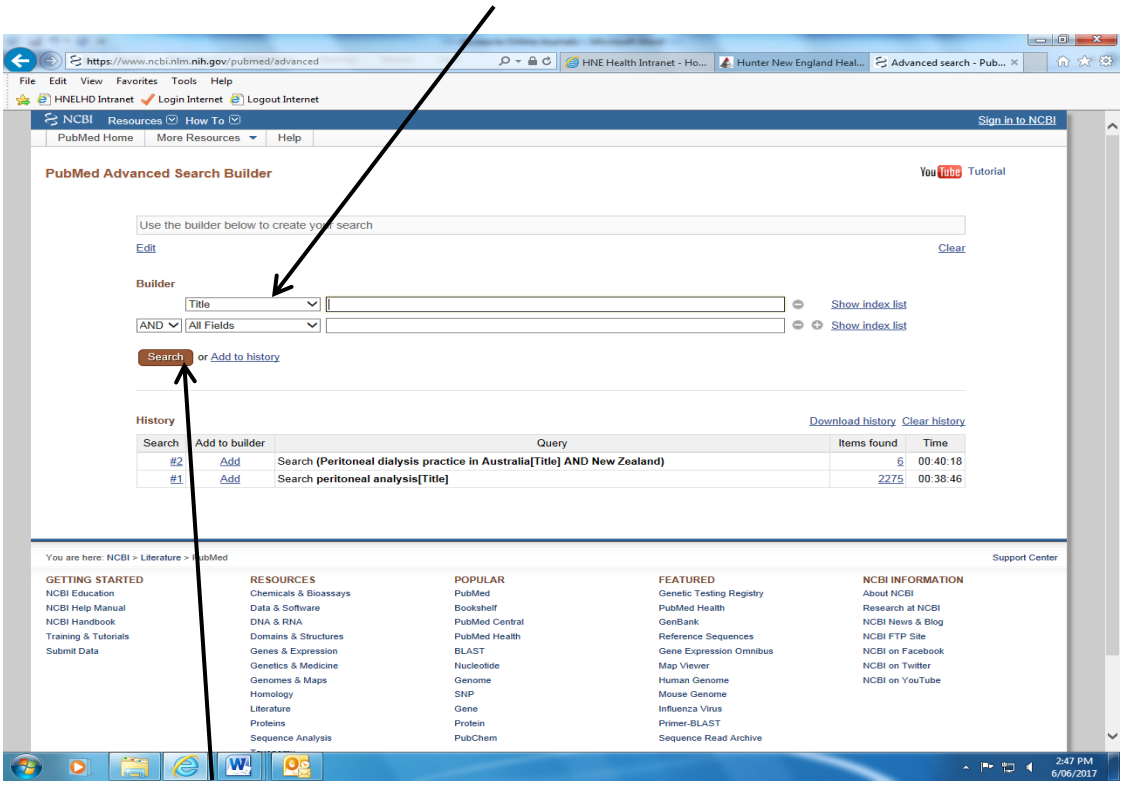
- Click on PubMed@HNE under Quick links on the right hand side of the screen



- Click on Advanced

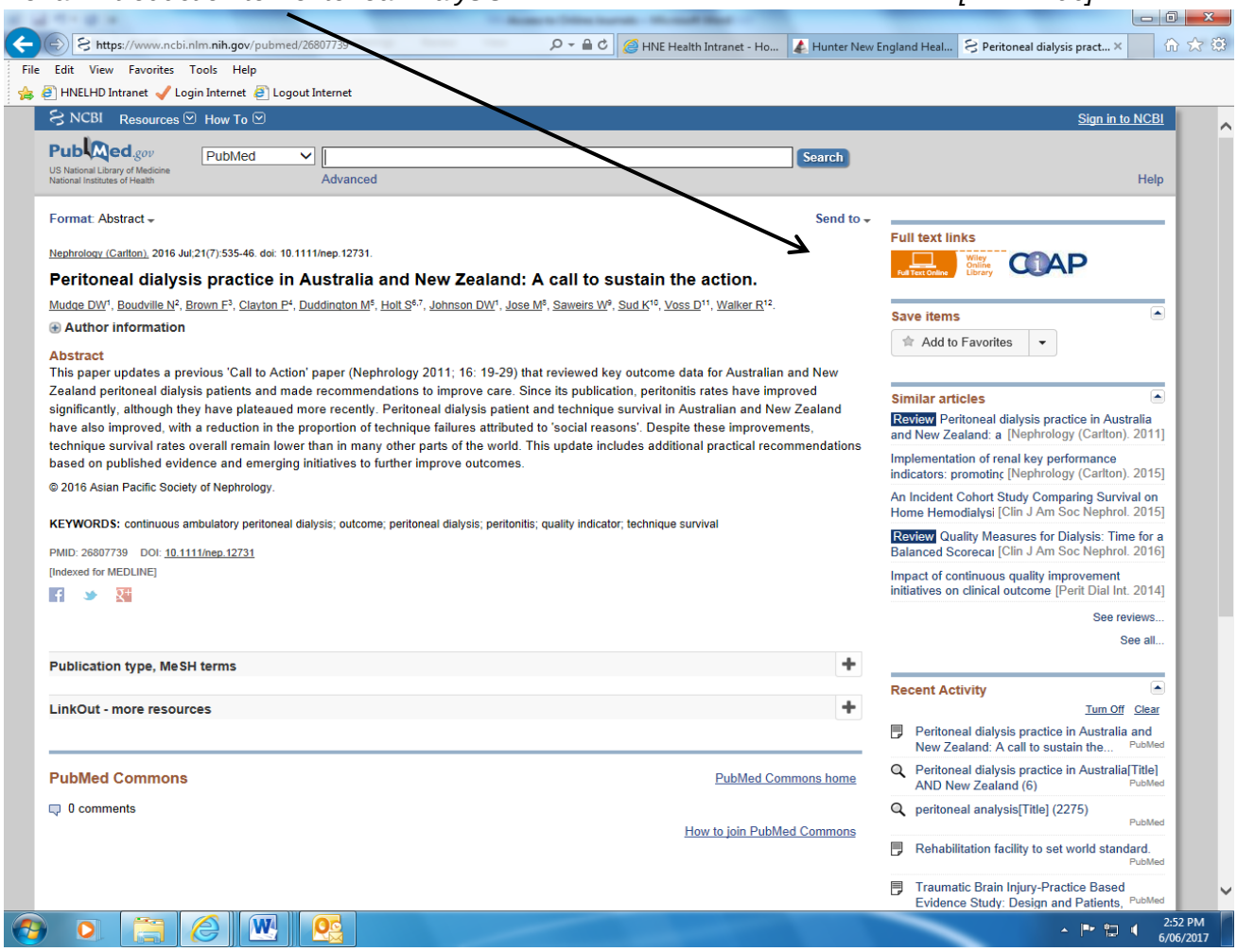


- Click on All Fields and change to Title



Type in the **full** title of the article and click Search

- Scroll down to find the required article and click on the title
- **Full text** links (**where available**) can be found on the right hand side of the screen



For further assistance contact your local HNELHD library.

Produced by Kerry Cuskelly and Helen O'Rourke – HNELHD, Tamworth Library services. June 2017

Additional resources / Further Information available from:

https://www.uptodate.com.acs.hcn.com.au/contents/search - search for Peritoneal dialysis
http://www.cari.org.au/ - Caring for Australians with Renal Impairment.
http://advancedrenaleducation.com/article/peritoneal-dialysis - Fresenius Medical - Advanced Renal Education site.
https://ispd.org/ - International Society for Peritoneal dialysis.
https://www.baxterprofessional.com.au/ - Education and resources for health professionals
http://www.renalsociety.org/education/one-online-nephrology-education/ - Renal Society of Australasia education portal.
https://www.niddk.nih.gov/health-information/kidney-disease/kidney-failure/peritoneal-dialysis - Patient education resources
https://www.uptodate.com/contents/peritoneal-dialysis-beyond-the-basics - Patient education resources
http://kidney.org.au/your-kidneys/support/dialysis/peritoneal-dialysis-home - Kidney Health Australia - Patient education resources

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HNE Guidelines and Procedures. Renal: Peritoneal Dialysis Catheter – Acute (Post Insertion) Exit Site Care

HNE Guidelines and Procedures. Renal: Peritoneal Dialysis Catheter – Chronic Exit Site Care

HNE Guidelines and Procedures. Renal: Baxter Freeline Solo Continuous Ambulatory Peritoneal Dialysis Exchange

HNE Guidelines and Procedures. Renal: Fresenius Stay Safe or Balance Continuous Ambulatory Peritoneal Dialysis (CAPD) Exchange

HNE Guidelines and Procedures. Renal: Peritoneal Dialysate and System Selection

HNE Guidelines and Procedures. Renal: Peritoneal Equilibration Test (PET) and 24 hour Adequacy Test

HNE Guidelines and Procedures. Renal: Adding Medication to Peritoneal Dialysis Fluid

HNE Guidelines and Procedures. Renal: Management of Peritoneal Dialysis Related Peritonitis
HNE Guidelines and Procedures. Renal: Peritoneal Dialysis Catheter – Management of Exit Site or Tunnel Infection
HNE Guidelines and Procedures. Renal: Management of Peritoneal Dialysis Catheter Extension Line Contamination

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Learning Package: Reflection on Learning

This document guides your reflection on the extent to which the package meets your professional development needs, and how you plan to apply your learning into practice. This tool is not part of the assessment process, and has been included as a document that you may wish to include in your professional portfolio. Time taken to complete learning package:_____

What was your purpose in completing this learning package?

_____

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Did you achieve this by completing the learning package?

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Reflecting on the content, what key learning have you obtained?

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What learning will you apply to your practice immediately? How will you do this?

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What learning needs have you identified as a result of completing this learning package?

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How do you plan to address these needs?

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Signature:_____Date:_____

Learning Package Evaluation Form

Your feedback regarding this learning package is important to ensure the package meets your learning needs. Please take 5 minutes to answer the following questions to facilitate any change required for future learning packages.

1. The learning outcomes of the learning package were clearly identified	Yes	No
2. The learning outcomes of the package were appropriate	Yes	No
3. The content provided enabled me to meet the learning outcomes?	Yes	No
4.The activities motivated my interest in the topic	Yes	No
5.The activities and workbook questions supported my understanding of the topic	Yes	No
6.The package was presented in a logical manner	Yes	No
7.The assessment process related to this package was clearly outlined (if applicable)	Yes	No

8. My most relevant learning outcomes from this package were:

_____

_____

9. The key learning points from this package I can immediately apply to practice include::

_____

_____

10. The least relevant component(s) of this package were:

_____

_____

11 Some suggestions I would like made to improve the package would be:

_____

_____

12. Further comments:

_____

_____

Thank you for your time to complete the evaluation
Return to: The relevant CNE/NE/CNC within your area.