Kidney Disease and its Implications

Module 1
PD Fundamentals

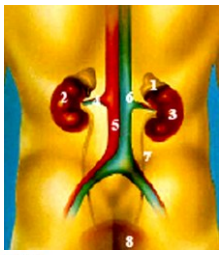
RR-RD-462 - March 2013

Learning Objectives

- Describe main functions of the kidney
- Understand acute and chronic kidney disease
- Know the main implications of kidney disease

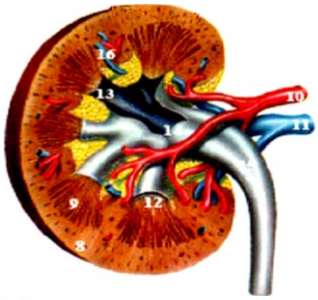
Kidneys

Kidneys are lima bean-shaped organs. A typical adult kidney measures approximately 12cm in length, 6cm in width, 3cm in thickness and weights about 150g.



1. Suprarenal gland
2. Left kidney
3. Right kidney
4. Renal artery and vein
5. Aorta
6. Vena cava
7. Right ureter
8. Bladder

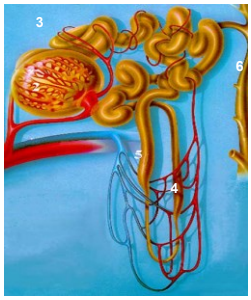
The Kidney



8. Cortex
9. Medulla
10. Renal artery
11. Renal vein
12. Major calyces
13. Minor calyces
14. Pelvis
15. Ureter
16. Interlobar artery / vein

The Key Unit of the Kidney: The Nephron

1. Glomerulus receives blood from renal artery
2. Filtrate formed from water and solutes filtering from glomerular capillary blood
3. Proximal convoluted tubule controls absorption (75 to 80%) of glomerular ultrafiltrate,



4. Descending loop of Henle is water permeable. This region is responsible for concentration and dilution of urine.
5. This region is responsible, along with the collecting duct that it joins, for absorbing water back into the body.
6. Highly concentrated urine is flowing into the collecting duct then into the pelvis and into the ureter

Functions of the Kidney

Homeostasis = Maintenance of equilibrium in terms of

- Salt and fluid balance (and blood pressure)
- Electrolyte balance
- Acid-Base balance (pH)
- Excretion of waste products

→ **The Kidneys**
- Filter
- Excrete
- Produce urine
- Reabsorb

Hormone production

- Active form of Vitamin D
- Erythropoïetin
- Renin and Angiotensin

→ **The Kidneys**
- Maintain healthy bones
- Produce red blood cells
- Control blood pressure

THE KIDNEY AND DISEASE

Classification of Kidney Disease

Two types of kidney disease

Acute kidney injury

- Classified according to site of problem: pre-renal, renal, post-renal
- Occurs over hours or few days
- Lasts hours to a few months, up to 1 year
- Could happen after injury or as a part of multiorgan failure
- **Usually is reversible**
- 50% mortality rate, major cause of death is infection

Chronic kidney disease (CKD)

Classified in 5 stages[1]

- 1: mild damage
- 2: mild decrease of renal function
- 3: moderate renal insufficiency
- 4: severe damage
- 5: end stage renal disease (ESRD)

Stage	Description	eGFR (ml/min/1.73m²)
1	Kidney Damage with Normal or ↑ eGFR 90	>90
2	Kidney Damage with mild eGFR	60-89
3	Moderate eGFR	30-59
4	Severe eGFR	15-29
5	Kidney Failure	< 15 (or dialysis)

1 K/DOQI Clinical Practice Guidelines for Chronic Kidney Disease: Evaluation, Classification, and Stratification; Part 4 Definition and Classification of Stages of Chronic Kidney Disease, Guideline 1: Definition and Stages of Chronic Kidney Disease, **NKF**, 2002

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Chronic Kidney Disease

Individuals at Increased Risk for CKD (Guideline 3[1])

Clinical factors associated with an increased risk for CKD

- Diabetes
- Hypertension
- Autoimmune diseases
- Systemic infections
- Urinary tract infections
- Urinary stones
- Lower urinary tract obstruction
- Neoplasia (cancer)
- Family history of CKD
- Recovery from acute kidney injury
- Reduction in kidney mass
- Exposure to certain drugs
- Low birth weight

Social factors associated with an increased risk for CKD

- Older age
- Ethnic minorities
- Exposure to certain chemical/environmental conditions
- Low income/education
- Smoking

1 K/DOQI Clinical Practice Guidelines for Chronic Kidney Disease: Evaluation, Classification, and Stratification; Part 4 Definition and Classification of Stages of Chronic Kidney Disease, Guideline 3: Individuals at Increased Risk for Chronic Kidney Disease, **NKF**, 2002

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Chronic Kidney Disease (CKD) – Stage 3

Defining CKD (Guidelines 1 & 6[1])

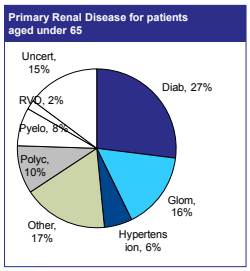
Kidney damage, as defined by structural or functional abnormalities of the kidney (with or without decreased GFR) as manifested by:

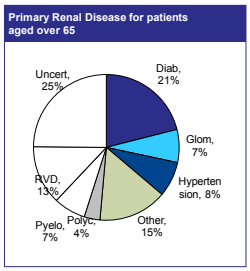
- Pathological abnormalities on a kidney biopsy
- Markers of kidney damage
  - Proteinuria
  - Hematuria
  - Red or White cells in urine
  - Abnormal imaging studies

Glomerular Filtration Rate (GFR) < 60 ml/min/1.73m2 (with or without kidney damage)

1 KIDOQI Clinical Practice Guidelines for Chronic Kidney Disease: Evaluation, Classification, and Stratification; Part 4 Definition and Classification of Stages of Chronic Kidney Disease, Guideline 1: Definition and Stages of Chronic Kidney Disease and Part 5 Evaluation of Laboratory Measurements for Clinical Assessment of Kidney Disease, Guideline 6: Markers of Chronic Kidney Disease Other than Proteinuria, NKF, 2002.

Causes of CKD – patients commencing dialysis





UK Renal Registry 2010 report

Consequences of CKD

When 75 - 80% of renal function is lost, every other organ system is affected

End Stage Renal Disease (ESRD) is a ***irreversible*** kidney disease

- <10 - 15% of renal function remaining

Patient must have dialysis, or a transplant, to prevent death.

Consequences of CKD

Uremic Syndrome - a collection of signs and symptoms that can occur with progressive CKD as ESRD approaches

Fluid and electrolyte disorders

Disordered function of other systems eg
- Anemia
- Hypertension
- Bone disease

Accumulation of uremic toxins leads to alteration in all body systems with general symptoms (nausea, poor appetite and tiredness)

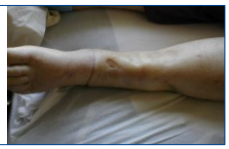
Manifestations of CKD

Chronic Kidney Disease can affect **every organ system** in the body

Alterations in Body Systems

Fluid balance/imbalance

- **Retention of water due to**
  - Volume overload and/or
  - Low serum albumin level
- **Hypertension**
- **Leading to**
  - **Shortness of breath**
  - **Oedema of ankles**



Alterations in Body Systems

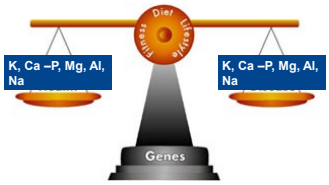
Acid/base balance (plasma bicarbonate < 22 mEq/l or arterial pH 7.4)

Signs and symptoms	CKD patients usually exhibit metabolic acidosis
• Increased rate and depth of respirations • Tachycardia in mild acidosis; bradycardia in severe acidosis • Altered mental status • Low blood pressure • Makes effects of hyperkalaemia worse • Various other complaints…nausea, vomiting, headache	• Retention of hydrogen (H) ions • Decreased re-absorption of bicarbonate • Decreased excretion of ammonium chloride • Retention of acid end products of metabolism • Catabolism producing more H and acidic metabolic products

Alterations in Body Systems

Electrolyte balance/imbalance

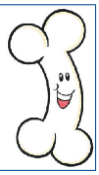
- Sodium
- Potassium typically ↑
- Phosphate typically ↑
- Calcium typically ↓ until replaced orally
- Magnesium
- Aluminum



Alterations in Body Systems

Bone problems - "renal osteodystrophy" – A complex set of biochemical and bone changes including within what is now known as CKD – Mineral and Bone Disorder (MBD):

- **Osteitis Fibrosa**
  - Bone pain
  - Calcium and phosphate are removed from the bones
  - Patient has low calcium, high phosphorus, high PTH, low vitamin D levels
- **Osteomalacia**
  - Bone pain, fractures, deformities
  - Demineralization of bone ("woven" bone)
  - High aluminum levels; altered osteoblast activity



Alterations in Body Systems

Hematologic system (blood)

- **Anemia**
  - Decreased RBC (red blood cell) production
  - Shortened RBC survival
  - Blood loss
- **Renal function blood tests**
  - Glomerular filtration rate (GFR) is decreased
  - Renal creatinine/urea clearances are decreased
  - Blood Urea (BUN) is elevated
  - Blood creatinine is elevated

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Alterations in Body Systems

Cardio-vascular system (heart and vessels)

- **Arythmias**
  - Hyperkalemia
- **Atherosclerosis and coronary artery disease**
  - Hyperlipidemia
- **Hypertension**
  - Retention of sodium and water
  - Renin-Angiotensin dysfunction
- **Pericarditis / effusion / tamponade**
  - Severe uremia can cause inflammation in pericardium

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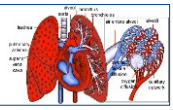
Alterations in Body Systems

Pulmonary system (lungs)

- Pulmonary edema
  - Fluid overload
- Increased respiratory rate and depth
  - Compensation for metabolic acidosis



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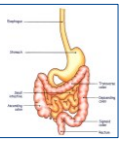
Alterations in Body Systems

Gastrointestinal system (stomach and intestines)

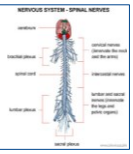
- **Anorexia, nausea, vomiting**
  - High uremic toxins
- **Constipation**
  - Causes can include medications (eg. Phosphate binding drugs)



Alterations in Body Systems

Neuro-muscular system (nerves and muscles)

- **Encephalopathy (severe uraemia)**
  - Headache, sleep problems, inability to concentrate
  - Tremors, twitching, seizures, coma
- **Neuropathy**
  - "Restless leg syndrome"
  - Burning feet
  - Weakness of proximal leg muscles

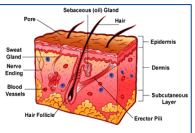


Both encephalopathy and neuropathy are due to uremic toxins, electrolyte imbalances and metabolic acidosis

Alterations in Body Systems

Skin

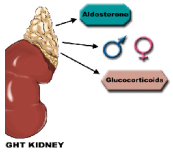
- **Gray-yellow color**
  - Retained pigments
- **Pallor**
  - Anemia
- **Dryness**
  - Decreased activity of sweat and sebaceous glands
- **Pruritus (itching)**
  - Deposition of calcium phosphate in the skin, low iron level
- **Bleeding/Infection**
  - Scratching to relieve itching
- **Bruising**
  - Abnormal blood clotting
  - Fragile capillaries
- **"Uremic frost"**
  - a white, powdery deposit of urea crystals that is left behind after perspiration dries
  - seen very rarely in very advanced renal failure



Alterations in Body Systems

Endocrine system (hormones)

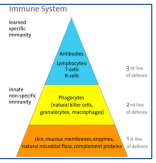
- Decreased somatotropin (exerts effect on growth hormone) in children
  - Needs good amounts of dietary protein, control anemia, control acidosis and/or
  - Human recombinant growth hormone (somatropin)
- Decreased reproductive ability/sexual desire
  - Testosterone, zinc for males
  - Counseling
  - Anemia therapy
  - May improve with better dialysis



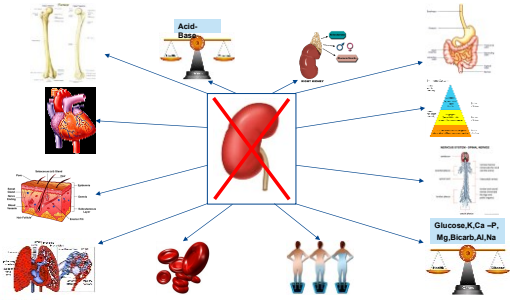
Alterations in Body Systems

Immune system

- Suppression of immune system
  - High level of circulating uremic toxins
  - Abnormal intake of nutrients for white blood cell (WBC) function
- More likely to get infection



Implications of CKD: Overview



Summary Points

- Kidney Disease may be Acute or Chronic
- Acute Kidney Injury may be reversible
- Chronic Kidney Disease can mean progressive permanent loss of renal function and it can be classified in 5 stages
- Two main causes of ESRD are Diabetes and hypertension/atherosclerosis
- Chronic Kidney Disease affects all body systems: Digestive tract, heart, muscles, nervous system, bones, skin, haematological system, immune system, endocrine system

The peritoneal membrane and how PD works

Module 2
PD Fundamentals

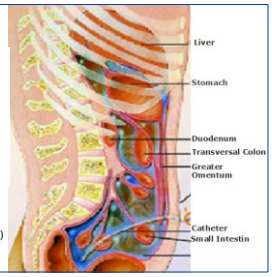
RR-RD-457 March 2013

Learning Objectives

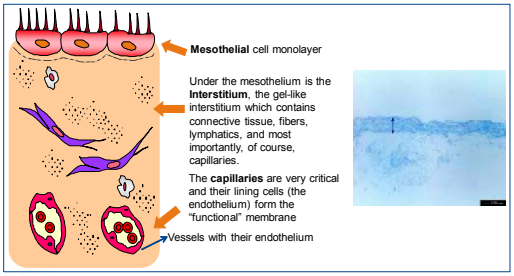
Gain knowledge of the anatomy and physiology of the peritoneal membrane and an understanding of how PD works

The peritoneal membrane

- The peritoneal membrane is a semi permeable fine layer of tissue that lines the peritoneal cavity, covering stomach, liver, spleen and intestines that are invaginated into the sac that it forms.
- It has a rich blood supply and is ideal for filtering wastes and extra water from the blood.
- Anatomical surface: ~1m²
- Functional surface and layers:
  - parietal: 10% (lining the front of the abdomen)
  - visceral: 60% (lining bowel and stomach)
  - omental: 30% (surrounding the omentum)



The normal peritoneal membrane



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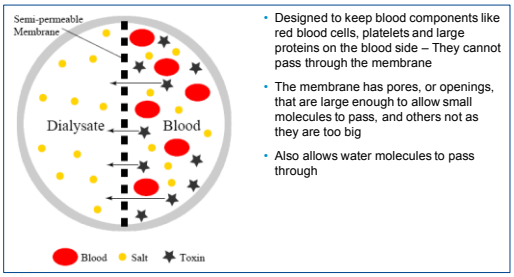
Semi permeable membrane is critical for dialysis



- Designed to keep blood components like red blood cells, platelets and large proteins on the blood side – They cannot pass through the membrane
- The membrane has pores, or openings, that are large enough to allow small molecules to pass, and others not as they are too big
- Also allows water molecules to pass through

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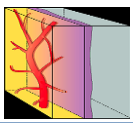
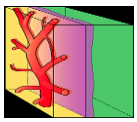
Peritoneal blood flow – the other side of the membrane

Vessel without PD	Vessel with PD
• A small part of the capillary is perfused (25%) • Flow rate: 50-80 ml/min	• Exchange surface of capillary increases • Flow rate: 100-150 ml/min





The effective peritoneal surface area, which is the critical point for dialysis, depends upon the degree of vascularity of the peritoneum as well as its surface area.

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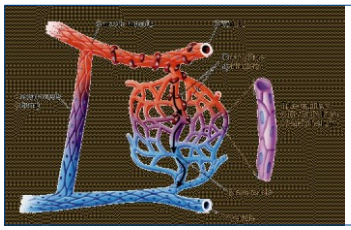
The capillary lining

Capillary: Main site of exchange of solutes and water



Capillar endothelium: believed to have 3 pores: large & small pores and aquaporins (water channels)

- Very small pores (2 - 5 A) (Aquaporin) - many of them, only allow water to pass and nothing else
- Small pores (40 - 55 A) - fewer of them, allow water and solutes
- large pores(150 - 250 A) – fewer of them, allow water and solutes

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HOW PD WORKS

PD FUNDAMENTALS Baxter

What do We Need to Perform PD

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9

What do We Need to Perform PD

A sensible doctor and an even better nurse….!!

- Natural semi-permeable membrane: the peritoneum
- A PD catheter to allow fluid to move in and out (exchange)
- A solution which dwells in the cavity and allows:
  - Removal of solutes
  - Absorption of solutes
  - Movement of water

What Happens During Dwell Time

Two fundamental processes

Body (blood) Dialysate

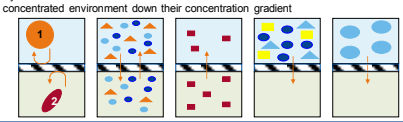
Solutes (toxins) *DIFFUSION*

Water *CONVECTION*

Solute clearance (diffusion) and Fluid Removal (convection)

Movement of solutes by Diffusion

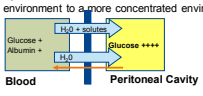
By the movement of solutes from a more concentrated environment to a less concentrated environment down their concentration gradient



Water movement by Osmosis - Pulled by osmotic pressure

Solutes will also move within the water (solvent drag)

By the movement of water from a less concentrated environment to a more concentrated environment



Diffusion

Key elements

- **Size of the solutes**: smaller molecules move more
- **Size of the pores**
- **Number of pores**
- **Concentration gradient for the solute concerned**:
  - gradient from the plasma to the dialysate: greater gradient, greater movement.
  - gradient will be maximum at the start of an exchange
  - will get less as the dwell proceeds
- **Effective peritoneal surface area**
- **Diffusive characteristics of the peritoneal membrane** (differs from one person to another)
- **Thickness of the membrane**: fibrous tissue in the interstitium will affect the transport/water movement.
- **Remember – glucose** will be absorbed over the dwell – so the osmotic gradient driving ultrafiltration will fall over the dwell – fluid could start to be reabsorbed into the peritoneum

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Transport by Diffusion -

	Plasma	Peritoneal membrane	Peritoneal cavity – fresh fluid
Urea (mmol/l)	30	→	0
Creatinine (µmol/l)	820	→	0
Sodium (mmol/l)	134	→	132
Potassium (mmol/l)	5,6	→	0
Bicarbonate (mmol/l)	21	→	0
Lactate (mmol/l)	<2	←	35 – 40
Calcium ionised (mmol/l)	1,1	←	1,25 – 1,75
Phosphorus (mmol/l)	2	→	0
Uric Acid (µmol/l)	460	→	0
Glucose (g/l)	1	←	15 - 45

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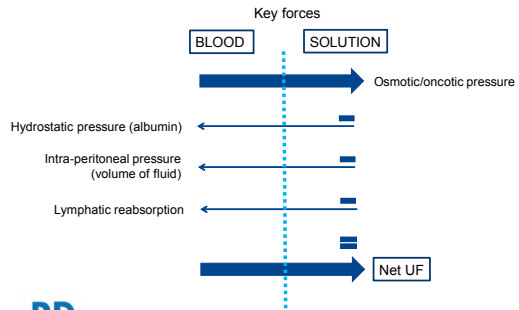
Fluid Removal – Net Ultrafiltration



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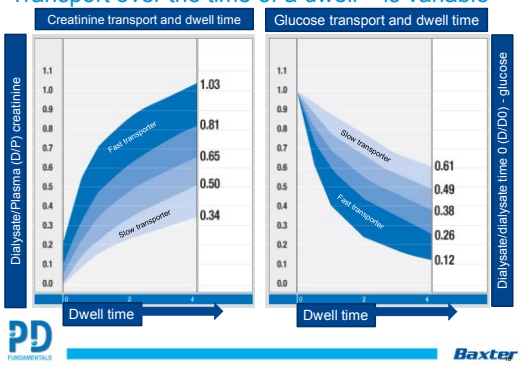
Transport over the time of a dwell – is variable



Conclusion

- A knowledge of peritoneal anatomy and physiology is important to help in the management of PD patients
- In particular: it helps to understand solute clearance and water movement and the different processes that are involved
- And it helps to understand how to prescribe PD to help meet targets for solute clearance and UF

Peritoneal Dialysis Access

Module 3
PD Fundamentals

Baxter

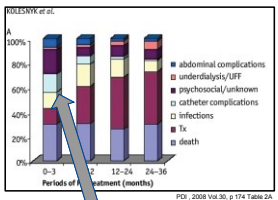
RR-Rd-460 March 2013

Learning Objectives

- Understand the importance of PD access
- Describe the key factors for successful PD access management
- Describe the main components of PD catheters
- List the different insertion techniques

Importance of PD Access management.

Reasons for transfers to HD



PDI , 2008 Vol.30, p 174 Table 2A

15% drop out because of catheter complications during 3 first months

More than 40% of the PD patients who switched to HD did so within the 1st year and more than 70% within the 1st two years – due to peritonitis or catheter related issues

Table 2. Causes of switching from peritoneal dialysis to hemodialysis

Causes of Switching	Number (%) N = 65
Infection (peritonitis and catheter-related)	24 (36.9%)
Cardiovascular (fluid overload)	12 (18.5%)
Abdominal surgery	8 (12.3%)
Pancreatitis/malnutrition	7 (10.8%)
Decreased mental capacity	2 (3.1%)
Abdominal wall defect	1 (1.6%)
Unknown	11 (16.9%)

BMC Nephrology 2009, 10:3, p 10, 26

The clinical goal is 80% catheter survival at 3 years
(PDI, 2005 Vol 25:135)

The key to successful PD access

- Preparation before catheter insertion and selection of the exit site is important
- Catheter must be inserted as a "permanent" access in a sterile surgical area
- Catheters to be inserted by an appropriately trained and stable team in a planned manner.* *The experience of the team is more important than the type of catheter used*
- Whenever possible, the catheter insertion should be ideally performed at least 2 weeks before starting peritoneal dialysis.
- Adherence to careful exit site care is the corner stone of successful PD access

Pre-operative

Key assessment

- Determine factors that may impair initial wound healing (eg: diabetes,steroids) and exit-site management
- Clinical status (chronic cough, steroids use, oedema)
- Nutritional status (malnutrition impairs healing)
- Presence of colostomy, gastrostomy or ureterostomy
- Evaluate for
  - Abdominal wall for rash and evidence of infection
  - Chronic impetigo under abdominal skin folds
  - Abdominal wall hernias that require repair

Pre-operative key activities

- Set up appropriate communication plan with surgeon for catheter placement and patient follow-up
- Screening for MRSA and nasal carriage of Staphylococcus Aureus
- Determine exit-site location that optimizes longevity and patient satisfaction
- Locate exit site patient seated and standing – ensure there is no skin crease when sitting.
- Choose appropriate catheter length and known operative methodology
- Use a standard protocol which includes: shower with antiseptic soap, bladder emptied, bowel preparation, IV antibiotic therapy with an anti-stapylococcal antibiotic 1h pre-op or at induction (Vancomycin or Cephalosporin)

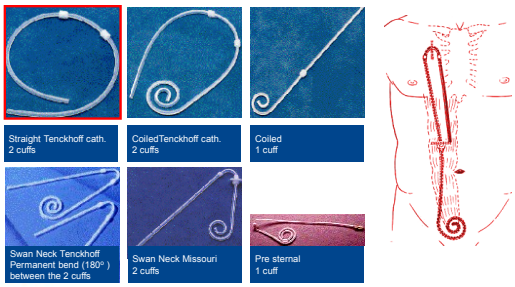
PD Catheters / The Choice

- Material: Silicone or Polyurethane with a radio opaque stripe
- The ideal catheter provides reliable, rapid dialysate flow rates without leak or infection*
- No particular catheter has been definitely shown to be better than standard silicone Tenckhoff
- **Double Dacron cuff catheters have shown reduced infection rates (exit site and peritonitis) versus single cuff in some but not all clinical trials**
- For the latest update on infection prevention guidelines, refer to: "**ISPD POSITION STATEMENT ON REDUCING THE RISKS OF PERITONEAL DIALYSIS–RELATED INFECTIONS" in** *Peritoneal Dialysis International,2011, Vol. 31, pp. 614–630*

* Peritoneal Catheters and exit site practices toward optimum ,Peritoneal Access: a review of current developments, PDI, Vol 25; 2005

PD FUNDAMENTALS Baxter 7

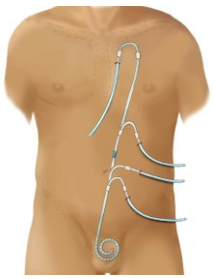
Types of Catheters



PD FUNDAMENTALS Baxter 8

One Size for All ? –
There must be flexibility in the choice of exit site

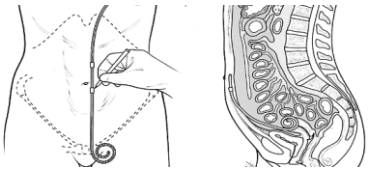
- Presternal
- Sternal (high)
- Abdominal central
- Abdominal low



Courtesy Dr Crabtree, CA, USA

PD FUNDAMENTALS Baxter 9

Choice of catheter insertion site



- For each style and size of catheter, the insertion site is determined by noting the deep cuff position* when the upper border of the catheter coil is aligned with the upper border of the pubic symphysis.
- Determine whether mid abdominal, high abdominal or pre sternal location is most appropriate for individual patient
- Catheter insertion exit-site location must be done patient seated and standing
- Mark exit-site location with indelible ink using stencils or actual catheter

* ISPD PD Access Guidelines 2005

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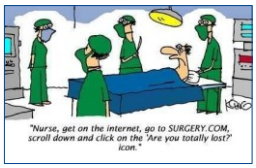
PD Catheter Implantation

Peritoneal Catheter implantation must be performed by a competent and **experienced surgeon or nephrologist**. Optimal long term peritoneal catheter function and exit site healing are directly related to the skills and the competence of the catheter insertion team.[1]



1 Gokal et al. Peritoneal catheter and exit site practices. Toward optimal peritoneal access.Perit Dial Int, 1998;18:11-33

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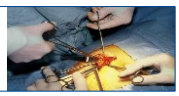
Implantation Methods

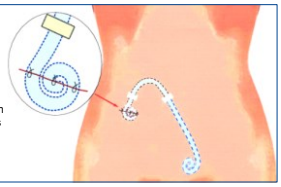
Open dissection



Laparoscopic

Percutaneous (Seldinger):

- Peritoneal cavity is entered with a needle and then a guidewire passes through the needle. The catheter enters the peritoneum through a peel away sheath.
- **Moncrief :**
- The external segment is completely buried in a subcutaneous tunnel . The entire wound is then closed for 4–6 weeks with no exit site, the catheter is then brought out externally before use.



Note: There is no technique of insertion of a peritoneal dialysis catheter that has consistently proven to be superior in the prevention of peritonitis. (Level II evidence): Guidelines **NEPHROLOGY** 2004; **9**, S65–S71

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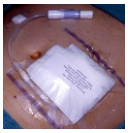
Catheter Insertion Recommendation

- Before inserting the catheter, eliminate air from catheter cuffs by soaking and gently squeezing cuffs in sterile saline solution
- The patency of the PD catheter should be checked during the procedure by running in and then draining out 1L of PD fluid.
- If the catheter does not function, then it should be repositioned immediately
- Catheter anchoring suture at exit site should never be used

Catheter Insertion Recommendation (1)

- Dressing should not be changed more than once a week during the healing period and must be performed by experienced PD nurses*
- Always keep the catheter well immobilized to the skin: this reduces the incidence of trauma and promotes tissue growth.



- Shower allowed (not soaking in bath) when the exit site is healed usually after 4 weeks to 6 weeks

Catheter Insertion Recommendation (2)

Avoid

- Constipation
- Tight fitting clothing around the exit site
- Submerging exit site in bath water
- Heavy lifting
- Manage any condition leading to severe coughing

Note: Never use alcohol or polyethylene glycol to cleanse catheter

First use of catheter for dialysis

- Whenever possible the catheter should be left for 2 weeks before starting PD
- Small dialysate volumes (1L) in the supine position can be used if dialysis is required earlier.

Accessories

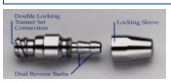
Titanium adaptor

Secure Seal
- Locking sleeve provides a snug compression fit
- Longer Tail and dual reverse barbs mean better catheter grip
- Patented double locking seal increases security of transfer set connection

Reduced Peritonitis Risk
- Seamless machining avoids rough surfaces that can tear catheters and catch debris
- Titanium, with twice the strength of steel and only half the weight, will not crack like plastic

Nursing Convenience
- The locking sleeve grips a wider range of catheter sizes
- Titanium stands up to disinfectants and resists corrosion

Patient Comfort
- Highly polished bullet shape feels smooth against the skin
- Superior machining minimizes size and weight



Conclusion

- No particular catheter has been definitely shown to be better than the standard silicone Tenckhoff
- Prophylactic AB at the time of insertion must be used (1g single dose IV)
- Exit site should be directed downwards or lateral – NOT upwards
- Sutures at the exit site should never be used

DO NOT FORGET

- A PD catheter is the patient's lifeline
- Good nursing care following guidelines and protocols will prevent complications and promote healing

PD program requirements

Module 7
PD Fundamentals

RR-Rd-469 March 2013

Essential Requirements for a PD Programme

PD is a simple technique

BUT

- Should be performed in the right setting
- With appropriate trained staff
- Adequate facilities
- As part of an integrated RRT programme

Essential requirements for a PD programme

I. Infrastructure and Facilities
II. Multidisciplinary team
III. PD patients management program
IV. Education and preparation of pre dialysis patients
V. Introduction of PD for the patient and his family
   A. Catheter placement at correct time
   B. PD Training program
   C. Out patient follow up
   D. Data collection and audit

Essential requirements for a PD programme

I. Infrastructure and Facilities

Suitable location for the PD Unit	• Location not important but best placed with a Haemodialysis centre. • Including 3 rooms if possible – Training room – Follow up room – Clinical office

Essential requirements for a PD programme

I. Infrastructure and Facilities

Training Room	• PD posters, brochures, booklets • TV and video – DVD player • Table + chairs (comfortable for patients) • Teaching Aids: Dummy patient… • Dressing trolley containing – Sterile materials : gauzes, gloves, syringes 2cc, 5cc, 10cc, 20cc, sterile towels … – Heparin, IV fluids and material for exit site care – Disinfectant solutions – Mask, micropore, scissors…

Essential requirements for a PD programme

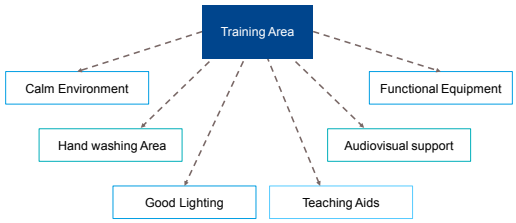
I. Infrastructure and Facilities

Training Room	• IV stand, white board and markers • Storage area for the PD material: PD solutions, titanium adapter, transfer set, minicap, HomeChoice cassette, Clamps

The presence of a sink, liquid soap and clean towels is necessary in the training room for hand washing

Essential requirements for a PD programme

I. Infrastructure and Facilities



Essential requirements for a PD programme

I. Infrastructure and Facilities

Follow up room for clinical assessment	• Bed for patient (if necessary) • Comfortable chair • Sphygmomanometer, weighing scale

Essential requirements for a PD programme

I. Infrastructure and Facilities

Office for doctors and nurses	• Computer: PD clinical software including clinical audit • Patients healthcare records • Calendar containing – Transfer set change and the PET test schedule – Medical visits and lab exams

Essential requirements for a PD programme

II. Multidisciplinary team – which ideally should include

- Medical team (Nephrologists, surgeon, microbiologist)
- PD Nursing Team
- Dietitian
- Social Worker
- Dialysis Administrator (fluid deliveries)

Essential requirements for a PD programme

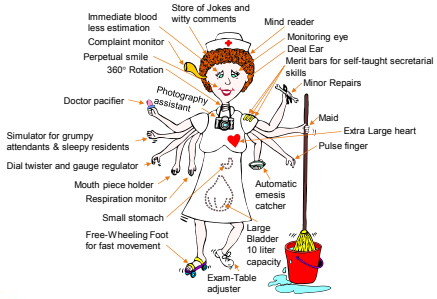
Nursing Staff

A Senior Nurse in charge

- Broad background in RRT
- Experienced in PD
- Leadership ability
- Adult education skills
- Ability to communicate and delegate
- Consistent/Firm/Flexible/Sense of humour

Other nurses join PD Unit as programme enlarges

The Model P.D. Nurse



Essential requirements for a PD programme

Nurse requirements

- 1 nurse for every 20-25 PD patients
- PD expertise required in the in patients unit
  - Post catheter care and admission of PD patients
- 24hr on-call cover when patients phone for advice
- Community care role if possible – home visits

Essential requirements for a PD programme

III. PD patient management program

A. Pre dialysis Education and Preparation
B. Introduction of PD to patient and family
C. Catheter placement at correct time
D. PD Training program
E. Out patient follow up
F. Data collection and audit

PD Patient management program

Why to start and How?

Pre-dialysis	• To reduce early anxiety stress and misinformation. • Patient, family, home assessment. • Introduce to patient group if it exists • Give written and audio visual information – show PD technique • Prepare the patient for transplantation

PD Patient management program

Introduction of PD for the patient and the family

Get them to understand the	• Different modalities of PD • Importance of hand washing • Following technique carefully • Importance of family support • What is needed in the home (existing rooms, storage needs)

Accommodation needs for PD

- Running water for hand washing near area selected for bag changes
- Shower/bathing facilities
- Storage area - bigger area needed for APD
- If on APD, room on a table by the bed for machine
- A sense of cleanliness in home
- Separate room not needed, just a dedicated area in a room - can be just a tray to put bags on
- Most patients homes will be suitable!

PD Patient management program

Catheter Implantation

Pre op	Refer to a surgeon and get an appointment for surgical assessment (if requested by the surgeon: anticoagulant, type of the catheter…)
	Re-assure the patient before the surgery
	Explain the operation procedure to the patient in a simple way
	Involve the patient to choose the exit site for his catheter
	Fix a date for the surgery and ensure training date and delivery are arranged

PD Patient management program

PD Training Program

- Ensure it covers all aspects of PD care
- Hand washing and technique training are the priority
- Availability of simple teaching aids
- Ensure a re-training after 6 months and after a peritonitis

The PD Nurse is responsible for the Training Program

PD Patient management program

Out Patient Follow up

- By PD nurses
- By doctors
- By all the team

In first 4 weeks ensure regular contact – home, hospital or by telephone

- Simple clinical/social assessment
- Reinforce training, especially fluid balance and recognition of peritonitis
- Medical review at **4 – 6 weeks** and 1 – 2 monthly thereafter (the patient will be consulted by the doctor and the PD nurse)
- If possible a clinic review at 1 – 2 weeks can be useful
- Take particular care to support the patient at home in the first 3 months

PD Patient management program

Data Collection and Audit

- Record of patient numbers
- Outcomes (survival, drop-outs)
- Hospitalizations
- Peritonitis rates
- Adequacy assessment
- Periodic audit of results and action planning to improve outcomes

Conclusions

A successful PD Unit depends on good management

The good management of a PD Unit depends on a confident, educated, motivated and professional nurse

Hygiene and Hand Washing

Module 8
PD Fundamentals

RR-RD-470 March 2013

Organisms have been around for a long time

Louis Pasteur

" Instead of hard working in killing microbes in wounds, wouldn't that be more reasoned not to introduce any"

French chemist and microbiologist. He discovered the relation between micro organisms and diseases and fermentation

Why all the fuss about hand hygiene?

The main mode of transmission to other patients is through human hands especially patients' or healthcare workers' hands

Prevention is primary action	In PD
• It remains the best protection against contamination • Prevent hospitalization due to infections • Avoid the spread of contamination	• Reduces the risk of peritoneal infection and so reduces acute hospitalisation with infection, loss of PD catheter and helps prolong peritoneal membrane integrity

Many personnel don't realize when they have bacteria on their hands

Nurses, doctors and other healthcare workers can get 100s or 1000s of bacteria on their hands by doing simple tasks, like

- Pulling patients up in bed
- Taking a blood pressure or pulse
- Touching a patient's hand
- Rolling patients over in bed
- Touching the patient's gown or bed sheets
- Touching equipment like bedside rails, over-bed tables, IV pumps

Culture plate showing growth of bacteria 24 hours after a nurse placed her hand on the plate

Note: Casewell MW et al. Br Med J 1977;2:1315

Transient and resident flora

Transient flora	Resident flora
• Colonize the superficial layers of the skin, • Are more amenable to removal by routine hand-washing. • They are often acquired during direct contact with patients or contact with contaminated environmental surfaces within close proximity of the patient. • Organisms most frequently associated with health-care–associated infections.	• Attached to deeper layers of the skin, • Are more resistant to removal. • Resident flora (e.g., coagulase-negative staphylococci and diphtheroids) are less likely to be associated with such infections. • The hands of HCWs may become persistently colonized with pathogenic flora (e.g., S. aureus), gram negative bacilli, or yeast.

Investigators have documented that, although the number of transient and resident flora varies considerably from person to person, it is often relatively constant for any specific person

Preventive measure that is vital for PD

" HAND WASHING "

Tips on how to wash your hands effectively

HOW you should wash your hands?

Before you start:

- Gather supplies needed for procedure
- Take off all hand jewelry
- Put on face mask

This *entire procedure should take two minutes:*

- When washing with soap and water *(40-60 seconds)*
- Completely wet hands with running water
- Apply enough antibacterial soap to cover all hand surfaces
- Using good friction, rub antibacterial soap over all parts of your hands creating a good lather for at least 20 seconds. Don't forget tips of fingers, thumbs, and backs of hands
- Rinse hands under running water
- Dry hands thoroughly with disposable towel
- Hold the tap handles with the disposable towel to turn it off so you don't get your hands dirty again
- Apply alcohol hand rub and rub your hands together until they are dry *(20-30 seconds)*
- Your hands are now clean
- Do not touch anything other than the PD exchange supplies or the patient's exit site

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Hand Washing

The most important thing you can do to protect yourself from germs and keep yourself healthy.

What you need: Clean water | Antibacterial soap | Clean disposable towels | Alcohol hand rub | Face mask

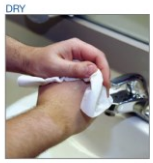
Before you start: Prepare clean work area | Gather supplies | Remove jewellry | Put on face mask | Remove catheter from under clothing

WASH

This procedure should take at least two minutes.

- Use plenty of clean running water and antibacterial soap[1]
- Using good friction, rub antibacterial soap over all parts of your hands creating a good lather for at least 20 seconds
- Wash well between fingers and underneath nails[1]
- Rinse hands under running water[1]

DRY



- Dry hands thoroughly on clean disposable towel[1]

DO NOT TOUCH ANYTHING

- Use clean disposable towel to turn off the tap[1]
- Apply alcohol hand rub and rub hands together until dry *(20-30 seconds)*[1]
- Do not touch anything until you start your exchange
- If you do touch something, wash and dry your hands again

PD FUNDAMENTALS Baxter

Tips on how to wash your hands effectively.

WHY washing your hands is important?

- Hands are a breeding ground for micro-organisms
- Everyone carries micro-organisms on their hands even though you cannot see them
- Incomplete or non-washing of hands, will increase the risk of micro-organism transfer to the patient, resulting in a greater chance of peritonitis and other infections
- Good hand washing and drying technique by clinical staff, patients, and caregivers, will reduce the risk of peritonitis and other infections, helping the patient continue to be healthy and stay on PD therapy longer

WHAT supplies you need?

- Clean water
- Antibacterial soap *(or local equivalent)*
- Clean disposable towels *(or local equivalent)*
- Alcohol hand rub *(dependant on local policy)*
- Face mask *(dependant on local policy)*

PD FUNDAMENTALS Baxter

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Tips on how to wash your hands effectively

WHEN you should wash your hands?
Thorough hand-washing must be completed by all clinical staff in the following situations:

- Before and after touching the patient
- After contact with the immediate patient surroundings *(e.g. chair, bed or clothing)*
- Before an aseptic technique is performed *(for example: a PD exchange or exit site dressing.*
- After exposure to body fluid
- Patients and all caregivers will be taught good hand-washing technique using a two minute scrub with friction prior to carrying out an aseptic technique such as a PD exchange or exit site care
- Thorough drying of the hands with clean disposable towels is essential after washing
- Patients may be taught to use alcohol hand rub when disconnecting from the cycler in the morning or at any time that they may be unable to wash with running water

Simple preventive measures in PD

- Always wash hands as recommended by Guidelines
- Train patients to do so
- At all time, execute PD techniques as recommended
- Always disinfect PD room after patient with infection attends
- Use adequate and clean material
- Keep windows and doors closed during PD technique
- Always throw the used material into a plastic garbage bin with cover
- Care givers to wear mask when doing PD
- Wear clean clothes and apron whilst providing care
- Monitor infections in PD patients
- Always remember that patients imitate what healthcare people do

Looking after the PD catheter exit site

Module 9
PD Fundamentals

RR-RD-471 March 2013

Learning points

- To understand why exit site care is important
- To understand the process of good exit site care in order to prevent infection

Overall exit site care

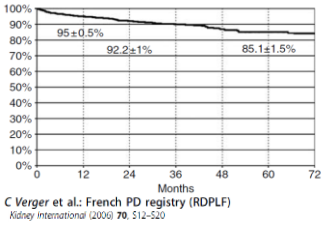
- Pre-, per- and post-operative care
- Properties of a good site
- Preventive measures

PD exit site

What is the "exit site"?	The position on the abdomen from which the peritoneal dialysis catheter emerges. 

Lifetime of a PD catheter

Actual lifetime of PD catheters can and should be long.



C Verger et al.: French PD registry (RDPLF)
Kidney International (2006) 70, S12–S20

The life of the PD catheter can be over 92% after 2 years and 85% after 5 years
(RDPLF – French language PD register)

The minimum target – 80% catheter survival at 1 year
(ISPD-2010 Vol 30, p 427)

Pre-operative care

- The patient should take a bath or shower using antiseptic soap
- Take a nasal swab to detect carriers of Staph. Aureus*
- Take this opportunity to inform and reassure the patient: this encourages the patient to cooperate
- Other actions:
  - I.V. antibiotic at the time of insertion
  - Bowel preparation
  - Ensure bladder empty

* ISPD Access guidelines 2010

Per-operative care

- Check patency with running in and out 1L PD fluid
- The exit site should be downwards facing and no sutures
- Non-occlusive dressing
- The catheter must be firmly immobilised: Follow its natural orientation
- Connect the transfer line and the MiniCap before putting on the dressing

Post-operative Care

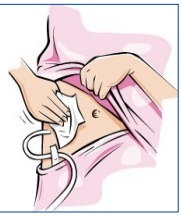
- Check whether the dressing is dry and the catheter is properly attached
  - To prevent pulling at the exit site
  - The catheter must be fixed in its natural orientation to prevent tension and irritation at the exit site
- Check the nasal swab result and treat as local policy
- Check the dressing carefully during the first few days: it must always be dry.

Post-operative care

- Do not open the first dressing between 7 and 15 days after the operation unless there is any significant leakage or haemorrhage.
- Check the dressing if clean and dry.
- Notify the doctor or surgeon if it is not and if leakage has occurred.
- If the catheter is not used immediately, there is no need to check whether it is working properly by flushing. (*ISPD access guide 2005*)
- Change the dressing no more than once a week for the first two weeks unless there is an infection (*European Recommendations 2005 Evidence C*)

Regular exit site dressing after PD commences.

- Use an aseptic technique, as instructed
- After the recovery period, it is advisable to change the dressing every day* *(European guidelines H evidence level C)*
- Do not handle or move the catheter more than necessary
- Inspect, list and record data on a special sheet used only for this purpose
- Throw the old dressing away before disinfecting your hands to apply a new dressing
- If there is a scab, do not use physical force to remove it.
- Feel very gently along the trajectory of the tunnel to check whether there is any pain: start near the midline and move towards the exit site



PD FUNDAMENTALS Baxter

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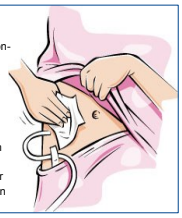
Chronic daily dressing

- Use soft material and make sure that material fibres do not become caught in the tunnel
- Individual centers may use different antiseptic solutions, but a non-irritant solution be used.
- You should use sterile saline solution once you think that the site has healed.
- Wear a mask and sterile gloves when changing dressings in the centre
- ISPD Guidelines (2011) recommends either
  - (1)daily applications of 0.1% Gentamicin ointment or cream to the exit site or
  - (2) Daily application of mupirocin ointment to the exit site or
  - *(3)* screening for MRSA carriage + then intranasal mupirocin if positive



PD FUNDAMENTALS Baxter

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Bathing and Showering

- Patients should not shower until the site has healed (after at least four weeks).
- Patients must always remove the dressing before taking a bath or shower and attach the catheter to their skin to avoid traction.
- Bathing in bathtubs, stagnant water, public swimming pools or Jacuzzis is not recommended: bathing in private swimming pools where the water is chlorinated or in salt water (sea) presents less risk of contamination *(ISPD Access guide 2005)*
- Patients should apply a fresh dressing after bathing using the **aseptic techniques which they have learnt**.

PD FUNDAMENTALS Baxter

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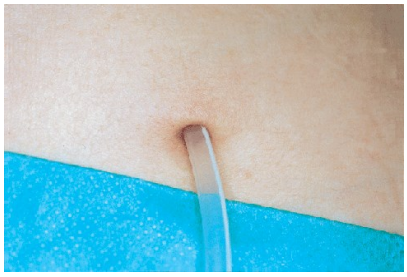
Instructions to patients – ISPD Recommendations

Recommendations ISPD 2011

- Inspect the catheter and the exit site every day
- Showers are preferable to immersion in a bath
- Clean the site with antiseptic soap when taking a shower
- To avoid contamination, do not pour leftover liquid soap from one container to another
- Use saline solution to soften scabs: never use physical force to pick them off.
- If you are using an antibiotic ointment to prevent infection, do not spread it straight from the tube onto your skin. Use a gauze pad and apply a small amount. *If your catheter is made of polyurethane, do not use mupirocin ointment
- Keep the catheter firmly immobilised to the skin all the time so that it cannot move
- Use dressings to prevent contamination
- Avoid getting constipated

Features of a healthy exit site

A Perfect Exit Site



Summary - the Nurse's role

Preventive is always better than cure

- Preparing the abdomen for surgery
- Choosing the exit site - avoid skin creases when the patient sits
- Taking swabs and giving treatment
- Training patients and their relatives in good PD technique
- Regular Audit of Exit site infection

Non Infectious Complications in Peritoneal Dialysis

Module 10
PD Fundamentals

RR-Rd-472 March 2013

Learning objectives

- Understand the main PD non infectious complications
- Gain knowledge around prevention / management of non infectious complications

Major complications

Mechanical complications

Occurring early after surgery
- Pain
- Bleeding

Occurring later after surgery
- Haemoperitoneum
- Poor outflow or inflow
- Leaks
- Migration of the catheter
- Increased IPP (Intra Peritoneal Pressure)
- Hernia
- Pain: infusion and drainage phases
- Eosinophyllic peritonitis at start of PD

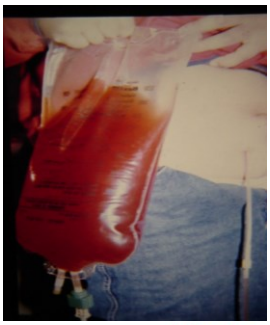
Early After Surgery

Pain	Bleeding
• Management of pain is important to maintain the patients comfort. • Avoid or manage severe cough	• Always assess if dressing is clean and dry • If bleeding persists, advise the surgeon

LATER AFTER SURGERY

Haemoperitoneum

- Can look dramatic but will usually settle with time
- Can occur with monthly menses
- May need additional heparin if there are signs of clots (but usually the natural anticoagulants from peritoneal cells will prevent any such problems

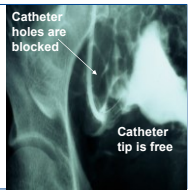


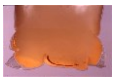
Poor Inflow or Outflow

Typically constipation and catheter migration are major causes of flow problems
Clinical features, patient typically reports slow CAPD exchanges or HomeChoice alarms

Causes

- Constipation
- Catheter migration
- Catheter obstruction with fibrin, blood
- Omental wrapping





Blood clot

Catheter Migration

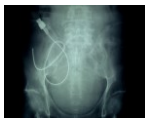
Migration of the catheter is defined if the tip is found not to be in the true pelvis

Predisposing factors

- Improper implantation or length
- Direction of the subcutaneous tunnel and "memory" of catheter may lead to migration of the catheter.
- Constipation

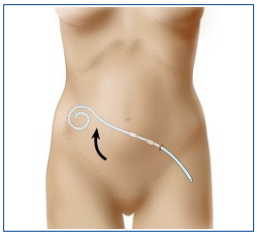
Prevention

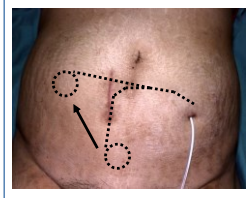
- Perfect catheter insertion technique
- Avoid and manage constipation



* PERITONEAL DIALYSIS : 1994 | Volume : 40 | Issue : 3 :170-8
Peritoneal access. Bhatta B, Khanna R, Twardowski ZJ

Catheter Tip Migration





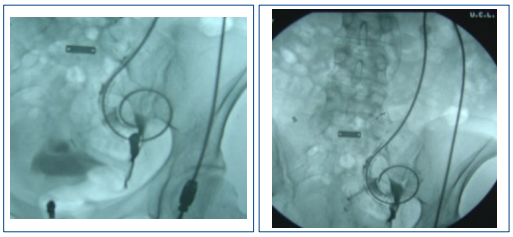
Catheter tip migration from catheter memory and poor deep cuff fixation.

Catheter Obstruction

2005 European Guidelines recommendations for management:

- Conservative strategies such as body position change
- Laxatives
- Flushing with heparinized saline ('push-and-suck' manipulation)
- Thrombolytic therapy (as per hospital's protocol eg Urokinase),
- Fluoroscopic-guided manipulation using a guidewire
- Surgery: will be possible laparoscopically
- We recommend that each PD unit should have the ability to manipulate or reimplant PD catheters when necessary

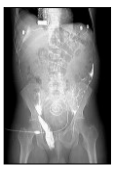
Catheter Related



Catheter obstruction: omental wrapping, managed by laparoscopic surgery with omentectomy/omentopexy

Hernia

- The most commonly seen hernias are incisional, umbilical and inguinal.
- Incisional hernias may occur when the peritoneal catheter is placed through the midline instead of the paramedial approach through the rectus muscle.
- Risk factors
  - Elderly patients
  - Diabetic patients
- Worsened by elevation of intra-peritoneal pressure eg catheter malfunction problem so drainage is incomplete and pressure rises driving a leak



Tintillier M et al; Lancet 2003;362:1893 inguinal hernia

* 2005 European Guidelines- D and E

Hernia

Considerations

- Assess and repair before starting PD
- Make sure reduction is possible – if not – then urgent surgical assessment
- Surgical repair is necessary - hernias should be corrected either before or at catheter insertion.*
- Stop PD temporarily around time of surgery
- Reintroduce PD with low volumes, supine posture, increase volume over 2 weeks

* 2005 European Guidelines- D and E

Leaks

Presentation :

- A leak may be observed directly through the exit site
- More commonly, swelling is noted in the groin region – fluid is moving down the tissue planes until it stops at the inguinal ligament in the groin
- Patient may notice weight gain but no signs of fluid overload

Site of leaking can be:

- Peri catheter
- Hernia
- Persistant processus vaginalis (a remnant of embryonic development)

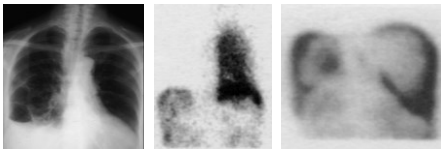
* 2005 European Guidelines- L

Leaks

Management of a leak

- Leakage through exit site: stop PD and consider catheter replacement
- Other leaks: remember the force causing leakage is a rise in intra-peritoneal pressure, so consider causes eg. Catheter migration, excessive prescribed volumes
- Decrease PD volumes, use dry day or stop PD if significant RRF
- Consider causes and investigate eg: CT with contrast medium in a standard dwell (performed by PD nurse)
- Manage the cause that is found and this may need surgical intervention

Peritoneal – Pleural Leak



Treatment:
- Stop PD for 4-6 weeks with transfer to HD if insufficient RRF
- Pleurodesis if recurs

Note: Kanaan N et al; Nephrol Dial Transplant 1999;14:1590-2

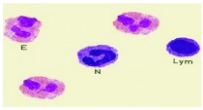
Infusion and drainage pain

	Causes	Management
Infusion	• Solution jet effect on peritoneal membrane • Often found to be PD fluid pH related	• Slower infusion speed • Use Bicarbonate IP (opinion) up to nephrologists recommendation • Use of biocompatible solutions. • Replacement of catheter if irritating peritoneal wall
Drainage	• Catheter pressing on peritoneal membrane or force of 'suction' is too strong • Drain time too prolonged	• Lift up the drainage bag a little, decreasing gravity • Ensure PD cycler is not too high • Tidal modality could be used on APD

Eosinophilic Peritonitis

Allergic reaction to the following
- PD catheter
- Lines and bags
- Intraperitoneal air
- Drugs: Vancomicin, gentamicin, streptokinase, cefalosporins.

Presentation
- Cloudy bag - but no symptoms
- High WBC count with 20% eosinos
- Usually early in the course of PD
- Usually slears spontaneously
- May be a sign of an infectious peritonitis eg fungal infection



Summary – Prevention is better than cure

- Appropriate selection and preparation of patients for PD therapy – repair hernias
- Catheter insertion program : All renal units should have clear protocols for peri-operative catheter care*
- All personnel involved with catheter insertion should be adequately trained*
- Train patients in early recognition and communication of problems
- Excellent training of PD staff to manage complications
- Training and regular follow up of patients by trained personnel, using appropriate training tools

* ISPD access guidelines 2010

PD infectious complications

Module 11
PD Fundamentals

RR-RD-473 March 2013

Learning objectives

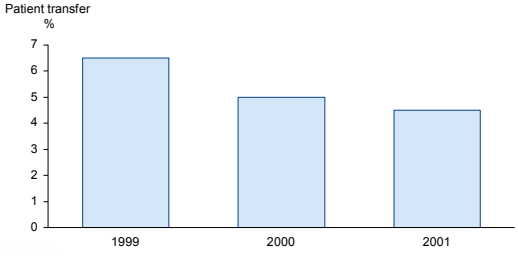
- Appreciate the main infectious complications in PD
- Identify Infectious complication symptoms and signs
- Understand reasons for infectious complications
- Describe best management of infectious complications

PD infectious complications

Infectious complications	• Exit site infection • Tunnel infection • PD-related peritonitis

Management of PD infectious complications has improved over time

Fewer patients transferred to HD during the first year on PD because of infection



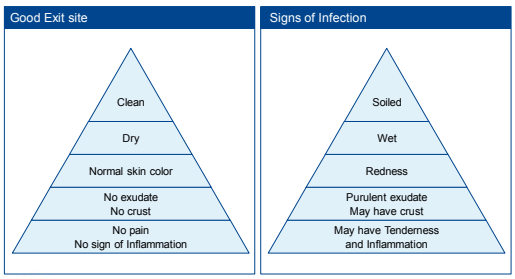
Note: Guo et al, Vol 64, Suppl 88, 2003

Relationships between infectious complications

Colonisation of exit site – very common

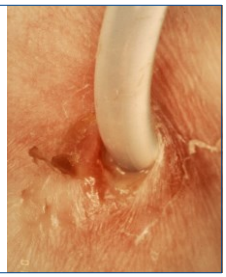
- Infection of exit site
- Tunnel Infection
- Peritoneal Infection
- Loss of PD catheter + Technique failure

Definition of exit site infection



Definition of Exit Site and Tunnel Infection

- Purulent drainage from the exit site indicates presence of infection; erythema may or may not represent infection (evidence)
- Positive culture and normal appearance is indicative of colonization rather than infection
  - Intensified exit-site cleaning is advised (opinion)
- Tunnel infection usually occurs in the presence of exit-site infection, but rarely occurs alone
- Pain whilst palpating the tunnel, can indicate infection in the tunnel



Note: Peritoneal Dialysis Related Infections Recommendations:, 2005 Update
Piraino, et al. *Perit Dial Int* March/April 2005

PD FUNDAMENTALS Baxter 7

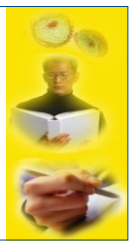
Evaluating the exit site

Look	Visual inspection of the exit site and sinus using magnification and adequate lighting
Feel	Palpation of the tunnel and the cuff for tenderness and induration (by experimented PD staff only)
Record	Make a note or a picture at every clinic visit to get an impression or memory of the exit site.

PD FUNDAMENTALS Baxter 8

Evaluating The Exit Site (cont'd)

Culture	• Any obvious and significant drainage • Culture results are commonly negative taken from infected exit sites while the patient is on antibiotic therapy
Compare	• Findings with previous exit site appearance
Classify	• Utilizing exit site classification worksheet
Document	• Findings using detailed and consistent documentation in the healthcare record



PD FUNDAMENTALS Baxter 9

Exit Site Evaluation and Monitoring

- Scoring system may be useful for exit site monitoring
  - Infection assumed if score ≥4 or purulent drainage present (even if no other signs)
  - Score < 4 may or may not represent infection

	0 points	1 point	2 points
Swelling	No	Exit only; < 0.5 cm	> 0.5 cm; and/or tunnel
Crust	No	< 0.5 cm	> 0.5 cm
Redness	No	< 0.5 cm	> 0.5 cm
Pain	No	Slight	Severe
Drainage	No	Serous	Purulent

Note: ISPD Recommendations 2005
Perit Dial Int 2005; 25(2) : 107-31

PD FUNDAMENTALS Baxter 10

Prevention of Exit-site Infections Exit-site Care

- Prevention of catheter infections (and thus peritonitis) is the primary goal of exit-site care – the patient needs to understand how important this is.
- Catheter immobilization to prevent trauma
- Antibiotic protocols against *S. aureus* are effective in reducing the risk of *S. aureus* catheter infections (evidence)
- Until healing complete (6 weeks): dressing changes by dialysis nurse or trained patient using sterile technique, exit-site kept dry
- Routine exit-site care by patient
  - Antibacterial soap and water – once daily
  - Hydrogen peroxide should be avoided
  - There is evidence for daily antibiotic prophylaxis with mupirocin cream or gentamycin cream*
  - Patients can be screened for nasal Staph aureus carriage and then given nasal prophylaxis*

* 2011 ISPD position statement on reducing the risk of PD related infections

PD FUNDAMENTALS Baxter 11

PERITONITIS

PD FUNDAMENTALS Baxter 12

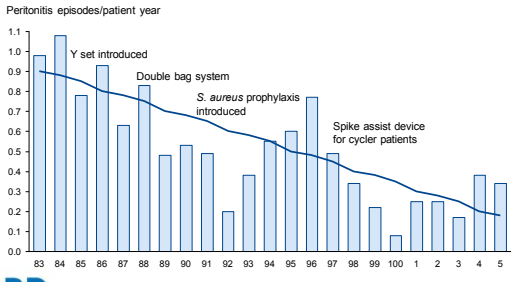
Peritonitis

Can be a cause of…	• Hospitalization and pain • Peritoneal membrane damage • Catheter loss • Technique failure • Death

Key factors about peritonitis

- Needs urgent assessment and treatment
- Culture of fluid – Needs to be done correctly
- Immediately start antibiotics IP into bag and leave for 6 hours
- Assess whether it can be managed at home or needs for patient admission
- Treatment continues for at least 2 weeks
- Antibiotics are changed according to what is growing
- ISPD 2010 Guidelines

Declining Infection Rates with PD as Innovations and Protocols are Introduced



Note: Bender, et al. Kidney Int. 2006;70(suppl 103):S44-S54.

Many patients will not develop peritonitis while on PD

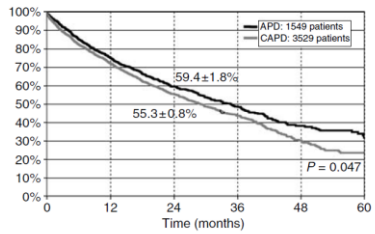


Figure 2 | Probability of being peritonitis-free in incident patients on APD and CAPD between 1995 and 2006. Curves were adjusted for comorbidity.

Kidney International (2006) **70**, S12–S20

Prevention of PD-related Infections Training Methods

- Training methods influence the risk of PD infections (evidence)
- Teach aseptic technique with emphasis on hand washing
  - If water is felt to have a high bacterial count, alcohol hand wash should be encouraged (opinion)
  - Hands completely dried after washing using a clean towel
  - Clean location for exchanges with no animal hair, dust-laden air, or fan
  - Re-train the patients after several months of PD – check technique

ISPD Recommendations 2005 Perit Dial Int 2005; 25(2) : 107-31
ISPD position statement on reducing the risk of PD related infections 2011
PDI 2010, Vol 30, #4

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Prevention of PD-related Infections Training Methods

- Teach patient to recognize contamination and the proper response if contamination occurs
  - Visit for a transfer set change if contamination occurs
- Prescribe prophylactic antibiotics if contaminated dialysate was infused or if catheter was exposed to air for a period of time
  - Most nephrologists give a 2-day course of antibiotics (opinion)
  - Effluent culture is helpful in determining subsequent therapy

Note: ISPD Recommendations 2005 Perit Dial Int 2005; 25(2) : 107-31

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Clustering and Tracking

- 50% of patients account for 90% of infections
- Patients with one infection episode are more likely to have another than those with none
- Most “repeat offenders” develop their infection early in the course of therapy: The earlier in dialysis history an infection develops, the more infection prone the patient continues to be.
- A high risk period for ESI/TI is in the 12 months post PD catheter insertion.

Note: Crabtree et al, ASAIO 45:574-80, 1999

Baxter

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Baxter

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PD-Related Peritonitis or Peritoneal Infection

Presentation:

1. Signs and symptoms (fever, nausea, abdominal pain, vomiting)
2. Cloudy effluent

Note: ISPD Recommendations 2010

Baxter

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Peritonitis Diagnosis

- Dialysate effluent should be obtained for laboratory evaluation (>4 hrs' dwell time):
  - Culture
  - Cell count, with differential
  - Gram Stain

Confirmation: WBC count >100/mm^3 , of which 50% are polymorphonuclear neutrophils (PMN), is confirmation of microbial-induced peritonitis

Note: ISPD guidelines 2010

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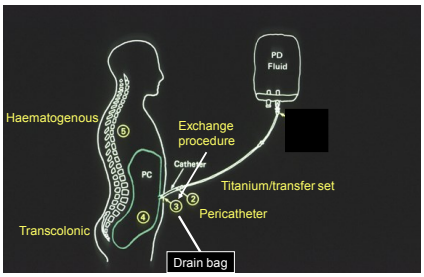
Routes of Peritoneal Infection



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Sources of Peritonitis, %

Touch Contamination	41
Catheter related	23
Enteric injury	11
Perioperative	6
Diarrhea/UTI	4
Sepsis	1
Unknown	14

Note: Harwell PDI 1997

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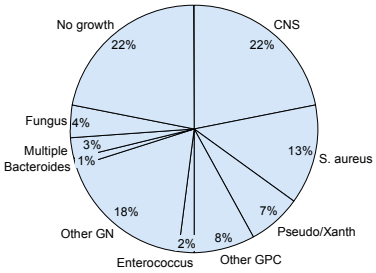
Micro-Organisms Causing Peritonitis



Identification of bacteria and routes of contamination

- Staphylococci coagulase -
- Staphylococcus aureus
- Pseudomonas-Xanthomonas

→ Touch

- Other Gram negatives → Not drying hands

- Enterococcus
- Bacteroïdes
- Multiple germs
- Yeast

→ Colon

- Culture negative → Consider alll

Initial Intervention at PD Unit

1. Initial assessment should not to be delayed:
   - cloudy fluid or abdominal pain = peritonitis
2. Performed by the patient or by the PD nurse: if patient did not bring his initial cloudy drainage
   - Disconnect drained bag and send sample to laboratory for cell count with differential, Gram stain and culture.
   - Dwell time should be at least one to two hours.
   - Standard culture technique is the use of blood culture bottles by culturing the sediment after centrifuging 50ml of effluent.

Note: ISPD Recommendations 2010 : *Pd related infections*

Initial intervention at PD Unit

- In presence of cloudy effluent with pain and/or fever:
- Consider 2 to 3 rapid exchanges to relieve discomfort as necessary
- **Initiate empiric antibiotic therapy within one hour while waiting for test results**
- In presence of very cloudy effluent or clot, add heparin 500 to 1000 U/L to new bag until effluent clears (usually 48 to 72 hours)
- Initiate adequate pain management.
- Assess the need for hospitalization or out patient management – many patients can and should be managed at hom

Initial, empiric antibiotic therapy

Empiric Antibiotic Selection	• Empiric antibiotics must cover both **gram-positive and gram-negative organisms (evidence)** • Selection of empiric therapy should be centre specific, dependent on the history of sensitivities of peritonitis-causing organisms in the centre • Gram-positive organisms may be covered by vancomycin or a cephalosporin **(evidence)** • Gram-negative organisms may be covered by a third generation cephalosporin or aminoglycoside **(evidence)** • Each unit should chose a single antibiotic regime and use every day

Note: ISPD Recommendations 2010-peritoneal dialysis – Related infections update

Initial antibiotic therapy

- Therapy is initiated immediately before causative organism is known
- Selection of antibiotics must be made in light of both the patient's and unit's history of micro-organisms and sensitivities
- Use both antibiotics even if gram stain sees gram positive or negative
- Commence anti-fungal therapy and remove catheter if fungus is observed

Continued treatment

- Adapt treatment once organism identified and antibiotic-sensitivities are known
- At 72 hours – if there is no growth on culture then this is defined as culture negative culture
- Catheter should be removed and/or changed if required clinically

Note: ISPD Recommendations 2010-peritoneal dialysis – Related infections update

Possible indications for catheter removal

Remember to save the patient first!! A catheter can be replaced.

- Refractory Peritonitis- failure of the effluent to clear after 5 days of appropriate antibiotics
- Relapsing Peritonitis- episode occurs within 4 weeks of completion of therapy with same organism
- Refractory exit site and tunnel infection
- Fungal peritonitis
- Specific organisms – TB, Pseudomona or Multiple enteric organisms
- Repeated episodes

Note: ISPD guidelines 2010- PD related infections

Baxter

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Complications of PD Peritonitis

- Temporary reduction of UF
- Increased protein loss
- Catheter removal
- Adhesions
- Transfer to HD
- Death

Baxter

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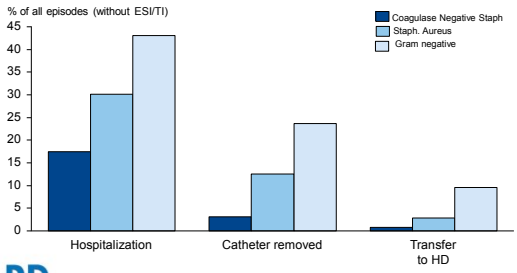
Outcomes of Peritonitis – variation between organisms

Outcomes are less good with Gram negative organisms and best with coagulase negative Staph (the commonest infection)



Note: Burke, et al., KI 1997

Baxter

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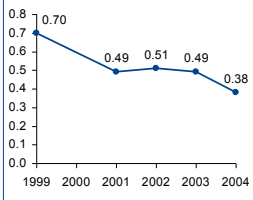
Management of PD Related Infectious Complications

The incidence of Peritoneal infections has decreased during the latest 10 years.

Peritonitis incidence/year

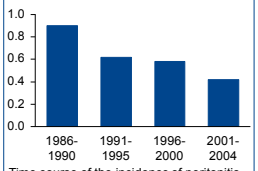
Peritonitis episodes/patient/year



Rémon et al, Nefrologia Vol 26 No 1, 2006

Peritonitis incidence over time

Episodes per patient and year



Time course of the incidence of peritonitis during the study period

Perez-Fontan et al, PDI Vol 25, 2005

Summary

Keys to low exit site and peritonitis rates include:	• Experienced personnel and careful patient training • Protocols for prevention, eg exit site care and management of infections • Hand washing technique • Continuous monitoring of rates and organisms in each centre

Adequacy in PD

Module 12
PD Fundamentals

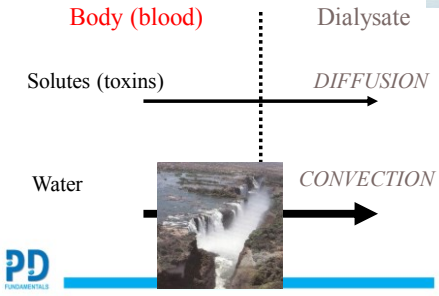
RR-RD-474 March 2013

Objectives

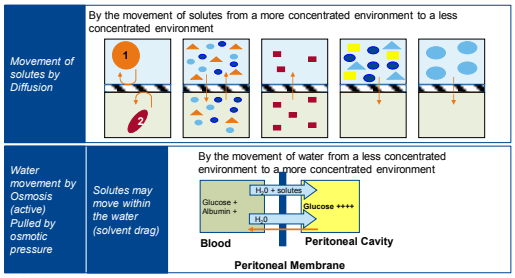
- Remember the principles of PD
- Understand the rationale for the Peritoneal Equilibration Test (PET) and how to do it
- Adequacy: definition, concept and targets
- Consider current targets that are associated with clinical guidelines
- Understand the principles of PD prescription management

What happens during the PD dwell

Two fundamental processes



Clearance and fluid removal



PD FUNDAMENTALS Baxter 4

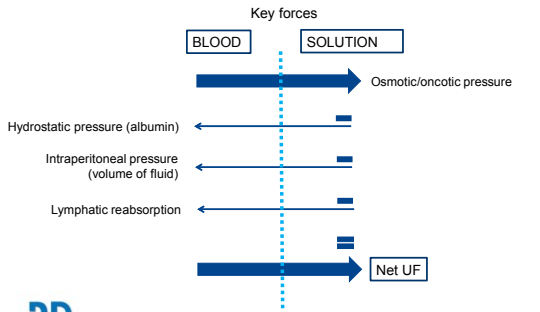
Diffusion

Key elements

- Size of the solutes: smaller molecules move more
- Size of the pores
- Number of pores
- Concentration gradient for the solute concerned:
  - gradient from the plasma to the dialysate: greater gradient, greater movement.
  - gradient will be maximum at the start of an exchange
  - will get less as the dwell proceeds
- Effective peritoneal surface area
- Diffusive characteristics of the peritoneal membrane (differs from one person to another)
- Thickness of the membrane: fibrous tissue in the interstitium will affect the transport/water movement.

PD FUNDAMENTALS Baxter 5

Fluid removal – net ultrafiltration



PD FUNDAMENTALS Baxter 6

Peritoneal membrane transport

- Knowing how the peritoneal membrane works in the patient is important to consider when individualizing the patients prescription.
- The Peritoneal Equilibration Test (PET) is used to define the membrane transport characteristics.
- The membrane is identified based upon the 4-hr equilibration between dialysate (D) and plasma (P) creatinine and glucose – a measure of how fast solutes are transported across the membrane
- The test also measures the effectiveness of the membrane in UF over a 4 hour dwell – defined as the UF capacity
- So there are 2 results from the PET which are both important – the D/P ratio and the UF capacity

PD FUNDAMENTALS Baxter

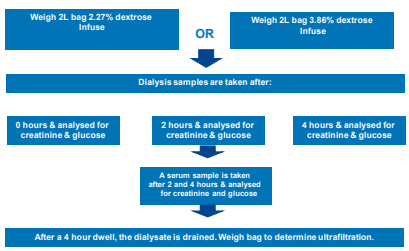
Peritoneal membrane transport

Assessed using the Peritoneal Equilibration Test (PET)

- A PET should be performed 4-8 weeks after initiating peritoneal dialysis to get a baseline assessment.
- The PET should be deferred at least 4 weeks and preferably for 8 weeks after resolution of a peritonitis episode.
- A PET can be done using either 2 litres of 2.27% or 3.86% and should always be done after a glucose dwell (CAPD or APD) and not following a dwell with a dry abdomen or icodextrin.
- The PET assesses both small solute clearance (the D/P creatinine) and ultrafiltration (ultrafiltration capacity).

PD FUNDAMENTALS Baxter

Peritoneal equilibration test procedure



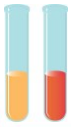
PD FUNDAMENTALS Baxter

Peritoneal equilibration test procedure

Based on measured results, the patient's D/P for creatinine and D/DO are calculated

The patient's 4 hour D/P will classify the patient as:

High | High Average | Low Average | Low transport type



Assessing Peritoneal Equilibration Test (PET) 4 hours

- Prescription management software can be useful to analyse and store the result

PET results

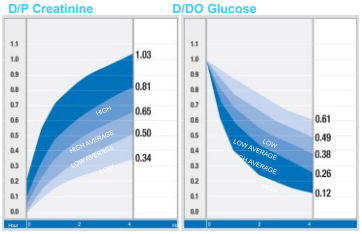
- The PET gives the membrane transport type of the patient (based on D/P creatinine) and ultrafiltration capacity.
- The ultrafiltration capacity helps to define ultrafiltration failure and at 4 hours should be:
  - 2L 2.27% > 200 mL
  - 2L 3.86% > 400 mL
- The PET results should be examined, used to guide PD prescriptions and recorded in the patients health care record for comparing results over time.

If discordance in D/P creatinine and D/D0 glucose is noted, it is recommended to repeat the PET.

Clinical assessment must be taken into account if results remain discordant

PERITONEAL MEMBRANE TRANSPORT TYPE

D/P Creatinine | D/DO Glucose



Membrane Transport Type	4-Hour D/P Creatinine
HIGH	.82 - 1.03
HIGH AVERAGE	.65 - .81
LOW AVERAGE	.50 - .64
LOW	.34 - .49

The transport types of "low" to "high" are also referred to as "slow" to "fast" by some clinicians.

Permission to use chart: Twardowski ZJ, Clinical Value of Standardized Equilibration Test in CAPD P of CAPD, Blood Purif 1988;7:95-108.

Quick quiz

- What will be the bigger problem with a patient who has a low transport membrane? Solute clearance or fluid removal? Why?
- What will be the bigger problem with a patient who has a low transport membrane? Solute clearance or fluid removal? Why?

Transport	UF	Clearance	Treatment
High Transporter	+	++++	Short Dwells - APD
High Average	++	+++	
Low Average	+++	++	
Low Transporter	++++	+	Long dwells - APD

Goals of PD therapy

" To provide patient with the best therapy improving life and lifetime on therapy"

Taking into account these factors to assess **adequacy** of dialysis:

- Patient symptoms
- Solute clearance
- Fluid status
- Blood Pressure control
- Nutritional status
- Quality of Life
- Compliance
- Control of infection
- Anemia correction
- Bone disease

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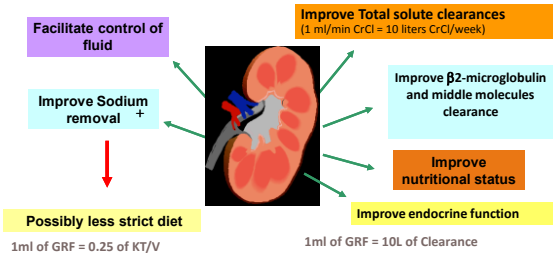
Adequacy of dialysis is not just solute clearance

Often we think of adequacy as just meaning urea KT/V but it is more than just that

- But thinking of that more narrow definition of adequacy it is important to measure solute clearance to assess the effectiveness of the patients current dialysis prescription.
- The prescription may be changed if the dialysis is not adequate but it is important to always consider the patients symptoms – a urea kt/v value may be above the adequacy target but if the patient has symptoms of "uraemia" such as poor appetite or tiredness then a prescription change may still be indicated

RRF is a vital part of dialysis adequacy and carries additional benefits



Tam, PDI vol 29 (2009) Supp 2
Bergstrom J. Kidney Int 1993;44:1045-57
Blake PG. Perit Dial Int 1996;16:243-5

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What do we need to EVALUATE to check adequacy of PD

- Clinical symptoms and signs
- Small solute clearance
  - **KT/V**: Urea clearance
  - **CrCl**: Creatinine clearance (corrected for 1.73 sq m BSA)
  - Both are used:
    - Peritoneal and renal components
    - Both require 24 hour dialysate and urine collections for measurement
    - Creatinine is a larger molecule and its removal in PD is more time dependent than urea
- While knowing - **Membrane transport status from PET**
  RRF

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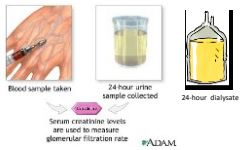
24hr Collection for KT/V and CrCl:

1.Urine

2. Dialysate

3. A blood sample



24hr collection procedure for CAPD patients:

1. Discard the first dialysate drainage of the day and the first urine in the morning.
2. Collect the urine and dialysate bags for 24 hours.
3. If residual function is low and the patient voids less than three times per day, obtain a urine sample for 48 hours and divide the volume by two.
4. Dialysate bags may be stored at room temperature.
5. Note the total volume of each drained dialysate bag.
6. Transfer all effluents into one container, mix and send a 100 ml sample to the lab (well identified - 24hr dialysate for Creatinine and urea) and send 24 hours urine collection for analysis of Creatinine and urea
7. In conjunction with the 24-hour collection, draw a serum sample and send to the lab for analysis of creatinine, urea (or urea nitrogen), glucose and albumin.
8. Be sure to obtain the patient's weight and height.

24hr collection procedure for APD patients:

1. Urine collection same as on CAPD
2. Start APD treatment in the evening as usual.
3. Throw the priming fluid
4. Save the dialysate from the "wet day" drained at this time.
5. Note the volume drained.
6. Dialysate may be stored at room temperature.
7. In the morning, collect the dialysate and measure the volume drained from the overnight infusions.
8. Note the total volume (volume from wet day plus volume from overnight infusions) that was infused for the 24-hour period.
9. If possible, infuse the "wet day" volume on day two manually in order to avoid diluting the effluent with unused dialysate. This might happen if the last fill is a different dextrose/glucose than that used at night.
10. Mix the bag thoroughly, draw a sample, and send to the lab for analysis of creatinine and urea.
11. Send the urine to the lab for analysis of creatinine and urea.
12. In conjunction with the 24-hour collection, draw a serum sample (should be taken before the afternoon if possible). Send to the lab for analysis of creatinine, urea, glucose, and albumin.
13. Be sure to obtain the patient's weight and height.

KT/V

60 kgs= 33 kgs VT

- **K** urea clearance
  - » Urea: end product of protein metabolism
- **T** time = 7 days for weekly KT/V
- **V** volume of urea distribution in the body (to normalize) (1)
  - » Corresponds to the total water in the body, = 55% (female) and 60% (male) of body weight
- Eg. Female weight 60kgs= 33kgs vt (55%)
- Weekly Urea Clearance

$$\frac{\text{Drain volume}}{\text{Distr volume}} \times \frac{\text{D (Dialysate urea)}}{\text{P (Plasma urea)}} \times 7$$

(1) Woodrow G, Oldroyd B, Wright A et al. Nephrol Dial Transplant 2003; 18: 384–389

Calculation of peritoneal urea clearance

Example:

Drain No	Dwell time	Drain Vol.	Drain urea
1	285	2500	11.9
2	285	2500	12.2
3	315	2625	10.0
4	597	2500	14.3

Plasma urea 14.1 Total drain vol = 10125 ml

Volume of distribution 31595 ml Average drain urea = 12.7

Calculation of peritoneal urea clearance

[redacted]

$$weekly\ Kt/v = \frac{10125}{31595} x \frac{12.7}{14.1} x 7$$

= 0.288 x 7
= 2.02

Creatinine clearance

- **CrCl:** Amount of blood cleared of creatinine expressed in L/week
- **Creatinine:** Waste product of muscle metabolism
- **Peritoneal clearance:**
  - Normalized to BSA (Body Surface Area);
  - CrCl x 1.73/ patient's BSA
- **Weekly peritoneal CrCl =** *Total Drain volume* x $\frac{D\ (Dialysate\ creat)}{P\ (Plasma\ creat)}$ x 7

Normalize to BSA

Calculation of peritoneal creatinine clearance

$$weekly\ creatinine\ clearance(l) = total\ drain\ volume\ x\ \frac{dialysate\ creatinine}{plasma\ creatinine}\ x7$$

= 10.7 x 0.788 x 7
= 59 l/wk

[redacted]

Monitoring frequency

- KT/V and Creat.clearance:
  - Within 4-8 weeks after initiating PD therapy
  - Every subsequent 6 month
  - If patients clinical status changes unexpectedly, or if prescription is altered, perform clearance measurements
- PET
  - 4-8 weeks after starting PD
  - Repeat if clinical changes or changes in peritoneal UF occur
  - Particularly important for APD patients

PD prescription

Components of prescription management

Patient factors

- Membrane function
- Lifestyle
- Body Size
- Residual Renal Function (RRF)
- Peritoneal pressure

Adjusted parameters

- Fill Volume
- Number of Exchanges
- Dwell Time
- Use of Total 24 Hours – short and long dwell
- PD solution
- Glucose Concentration

PD Adequacy guidelines
European Guidelines 2005 (EBPG)

1. Adequacy targets for dialysis should include both urea removal and fluid removal. *(Evidence level C)*
2. These targets should be based on those achieved by peritoneal dialysis only. Urine production and renal urea clearance can be subtracted from the targets. (*Evidence level C)*
3. The minimum peritoneal target for Kt/V urea in anuric patients is a weekly value of 1.7 *(Evidence level A)*
4. The minimum peritoneal target for net ultrafiltration in anuric patients is 1.0 l/day.*(Evidence level B)*
5. The presence of residual renal function can compensate when these peritoneal targets are not achieved. *(Evidence level C)*

PD Adequacy guidelines
European Guidelines 2005

- D. When the targets are not achieved, patients should be monitored carefully for signs of overhydration, uremic complaints and malnutrition. Appropriate therapy changes might be considered.
  (Evidence level C)

- E. Some APD patients who use frequent short exchanges and have a slow transport status can fulfill the above targets, but may have a low peritoneal creatinine clearance. In these patients, an additional target of: 45 l/week/1.73m2 for peritoneal creatinine clearance should be aimed at in addition to achieving the Kt/V urea target of 1.7. *(Evidence level C)*

How to change the prescription if target small solute clearance is not met.

- Remember RRF adds to peritoneal clearance – it is the total kt/v which should be higher than 1.7

- Need to consider the patients RRF and their membrane transport

ACHIEVING MINIMUM RECOMMENDED SMALL SOLUTE CLEARANCES

Shown below is general guidance to increase small solute clearance if urea Kt/V target is not achieved.

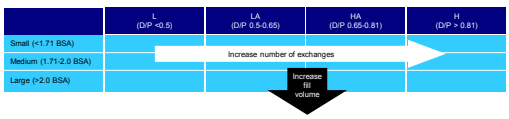


Figure illustrates the need to increase the number of exchanges as D/P creatinine rises and to increase fill volume the greater the body size.

ACHIEVING MINIMUM RECOMMENDED SMALL SOLUTE CLEARANCES

Therapy Optimization

CAPD

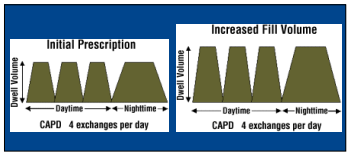
- Increase fill volume (start during night time dwell due to supine position)
- For patients without residual renal function, large BSA, and higher transport type, a fifth exchange may be helpful (monitor for adherence and quality of life)
- Higher transport patients - may benefit from a switch to APD

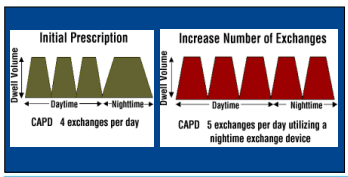
APD

- Add daytime dwell (1-2.5L) or increase fill volume
- Increase fill volume on cycler
- Increase time on cycler (balance quality of life)
- Increasing number of cycles - without lengthening time on cycler may not increase small solute clearance but will impair sodium removal
- Addition of an extra daytime exchange (4-6pm) is an efficient way to increase clearance

PD FUNDAMENTALS Baxter

Prescription Modification

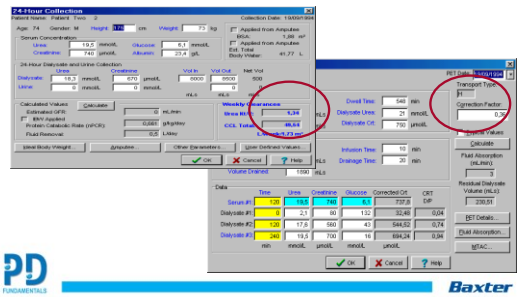




PD FUNDAMENTALS Baxter

The use of PD Adequest software

PD prescription model designed to help develop PD prescriptions



PD FUNDAMENTALS Baxter

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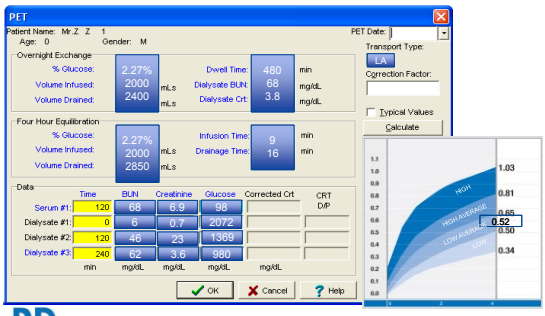

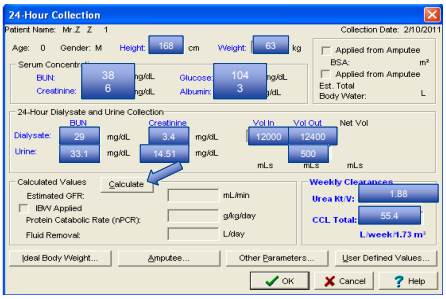

Summary

- Adequacy of PD should be checked regularly with a combination of clinical and laboratory measurements
- Small solute clearance should be measured with a key target of total (renal and peritoneal) kt/v of greater than 1.7
- Knowing the patients size, RRF and membrane transport then allows a logical PD prescription change to improve small solute clearance

Fluid management in PD

Module 13
PD Fundamentals

RR-RD-475 March 2013

Objectives of module

- Understand the principles of how fluid moves across the peritoneal membrane and what is meant by fluid balance
- Appreciate the importance of RRF in maintaining fluid balance
- Understand how PD can be prescribed to ensure fluid balance

What is the problem?

- Failing kidneys struggle to excrete salt and water
- Patients continue to drink fluid each day
- The tendency to develop is fluid overload is common in end stage renal failure
- Hypertension is also very common and fluid overload is an important cause
- BUT – preserving RRF is important as it brings clinical advantages

The importance of fluid management

- Symptomatic fluid retention noted in 25% of PD patients
  - 98% experiment lower extremity oedema
  - 76.1% pleural effusion
  - 80.3% pulmonary congestion *
- High prevalence of Hypertension and cardiovascular disease among ESRD population
- Cardio vascular disease is the major cause of death in Dialysis patient**

*W.Chen et al_ISN_2008; * Tzamalouka AH, et al, J Am Soc of Nephrology 95;6: 198-206; **Herzog et al_NEJM_1998

Baxter

4

Goals of fluid management in PD

- Reduction in Symptomatic Fluid Retention.
- Blood pressure control:
  - Preservation of Residual Renal Function.
  - Prevention or mitigation of Cardiovascular Disease (IHD, LVH, CHF, CVA, PVD).
  - Reducing accelerated atherosclerosis process.
  - Prevention of symptoms simulating uremia.
- Reduction in mortality.

Baxter

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Clinical goals of fluid management in PD

- Avoid hypovoleamia and hypotension
- Avoid hypervoleamia and hypertension
- **At same time** - avoiding excessive unnecessary use of hypertonic glucose solution
- **By** - Empowering the patient to manage fluid balance using a dry weight, keeping PD exchange records and understanding how to vary glucose strength to maintain fluid balance

Baxter

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Dry Weight Definition

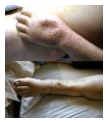
- Ideal oedema “free” weight with normotension and with minimal use of hypertensive medication
- Also can be defined clinically:
  - the weight below or over which further removal or
  - additional fluid results in signs and symptoms of
  - dehydration or over hydration

Dry weight will need to change over time as patients gain or lose fat or muscle

PD FUNDAMENTALS Baxter 7

Fluid overload - hypervolaemia

- Signs of fluid overload
  - Increased weight
  - Oedema of ankles
  - High blood pressure
  - Shortness of breath



Tzamalouka AH, et al, J Am Soc of Nephrology 95;6: 198-206

PD FUNDAMENTALS Baxter 8

Hypovolaemia

- Signs:
  - Low blood pressure
  - Dizzy feeling
  - Cramps
  - Weakness, fatigue
  - Weight below dry weight
- **May be because of vomiting/diarrhoea or because of excessive UF**

PD FUNDAMENTALS Baxter 9

RESIDUAL RENAL FUNCTION

Its role in fluid management in ESRD

Residual renal function- its important role in Fluid balance

- Residual renal function contributes significantly to the maintenance of euvolemia and to small solute and middle molecule clearances.[1]
- It is important to measure and preserve this function in patients with chronic kidney disease and in patients receiving PD or HD.
- There is evidence that RRF is associated with increased survival in studies[1] where both peritoneal and kidney components are measured.
- When the CANUSA data was re-analysed, it became evident that it was kidney clearance and urine volume that predicted survival in PD and not peritoneal clearance.

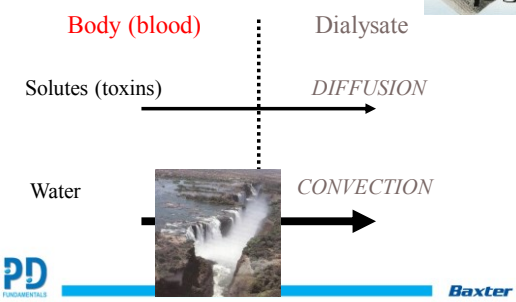
Managing residual renal function

- Regular re-evaluation of RRF
- Awareness of RRF contribution to total fluid removal
- Use diuretic – furosemide 250mg/day if urine output > 200 mls per day
- Avoid nephrotoxic drugs and X ray contrast media
- Avoid dehydration and excessvive UF if not needed clinically
- Use ACE inhibitor or Angiotensin II receptor blocker

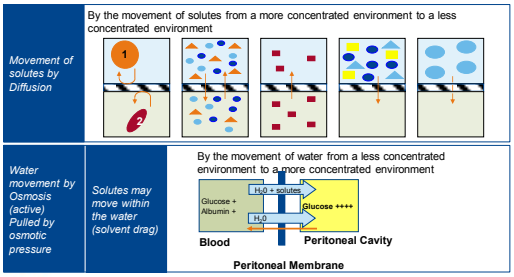
FLUID MOVEMENT AND PD

What happens in the PD dwell

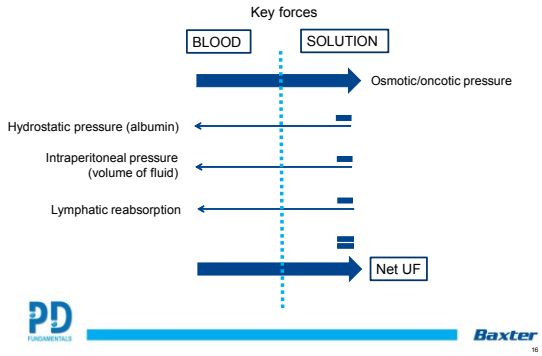
Two fundamental processes



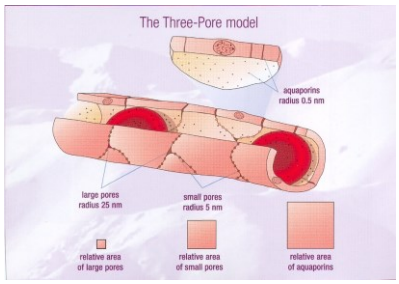
Clearance and fluid removal



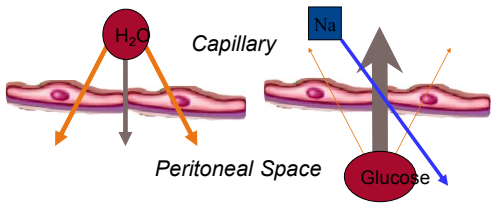
Fluid Removal – net ultrafiltration



Water moves by 3 pores – and only it can move through aquaporins, solutes cannot

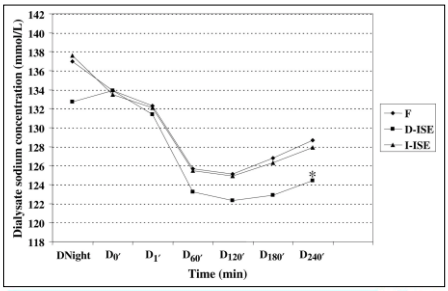


Physiology of Ultrafiltration: Structure of peritoneal membrane



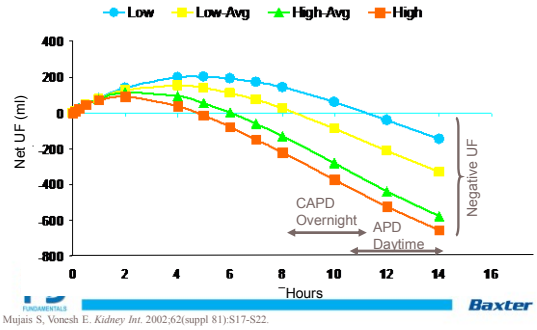
- Aquaporin mediated: 50%
- Intercellular: 50%
- Glucose transporter mediated: minimal
- Intercellular: >90%

Physiology of UF – early in a dwell more water is moving alone through Aquaporins - Sodium Sieving with 3.86% Glucose



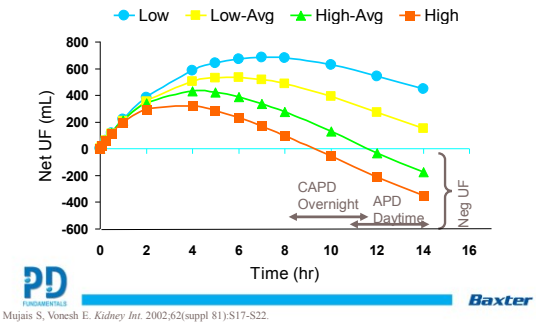
LaMilia et al, Nephrol Dial Transplant (2004) 19: 1849-1855- fig.2

Physiology of Ultrafiltration: Net Ultrafiltration Profile: 1.36% Glucose



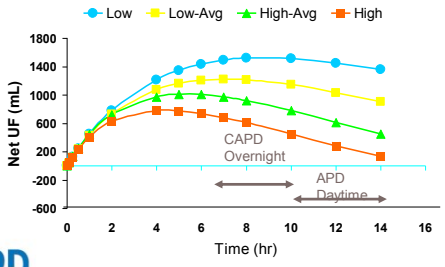
Mujais S, Vonesh E. *Kidney Int.* 2002;62(suppl 81):S17-S22.

Physiology of Ultrafiltration: Net Ultrafiltration Profile: 2.27% Glucose



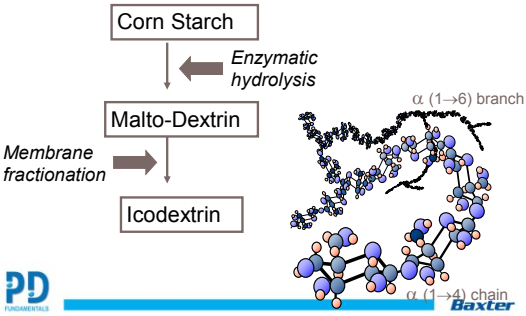
Mujais S, Vonesh E. *Kidney Int.* 2002;62(suppl 81):S17-S22.

Physiology of Ultrafiltration: Net Ultrafiltration Profile: 3.86% Glucose

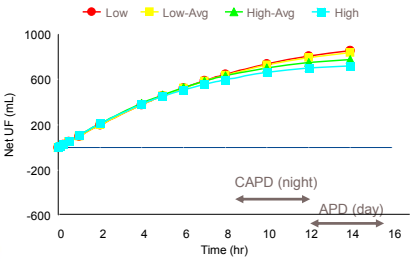


Mujais S, Vonesh E. *Kidney Int.* 2002;62(suppl 81):S17-S22.

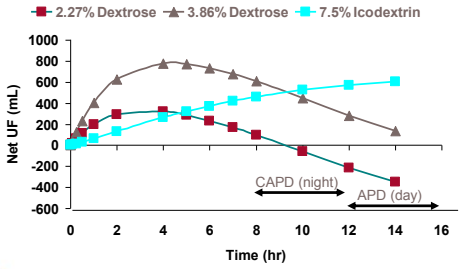
Colloid Osmosis: source and structure of Icodextrin



Fluid Management in PD: Icodextrin – most UF is through intercellular pores so less dependency on Transport Status. Ideal long dwell solution

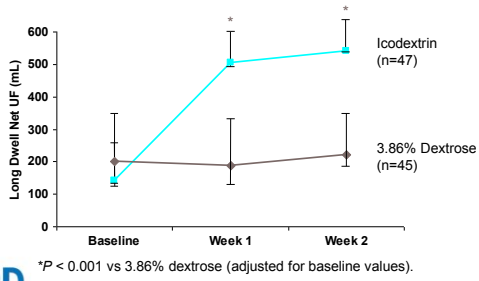


Fluid Management in PD: Icodextrin Comparison with 2.27% and 3.86%



Mujais, S, Vonesh E. *Kidney Int.* 2002;62(Suppl 81):S17-S22
Data on file, Baxter Healthcare Corporation. (courtesy)

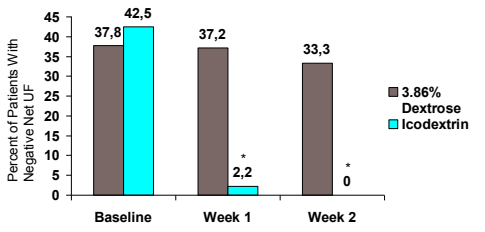
7.5% Icodextrin vs 3.86% Dextrose for APD Long Dwell: High Transport Trial – greater UF with Icodextrin



*P < 0.001 vs 3.86% dextrose (adjusted for baseline values).

Finkelstein,..,Abu-Alfa et al. *J Am Soc Nephrol* 2005;16:546-554

7.5% Icodextrin vs 3.86% Dextrose for APD Long Dwell: High Transport Trial – fewer patients with negative net UF in long dwell



*P < 0.0001 vs 3.86% dextrose

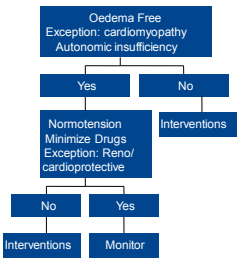
Finkelstein, Abu-Alfa et al. *J Am Soc Nephrol* 2005;16:546-554

Optimal Fluid Management: ISPD Guidelines

- Routine standardized monitoring and awareness of PET status
- Dietary counseling of appropriate salt and water intake.
- Protection of Residual Renal Function (RRF).
- Loop diuretics if RRF present.
- Patient education for enhanced compliance.
- Minimizing use of hypertonic glucose and monitoring for suboptimal UF response as a warning sign for possible ultra-filtration failure.
- Preservation of peritoneal membrane function.
- Hyperglycemia control.

Mujais, et al. *Perit Dial Int.* 2000;20(suppl 4):S5-S21
Lo Wai-Kei et al: *Perit Dial Int.* 2006; 26: 520–522

Optimal Fluid Management: Algorithm

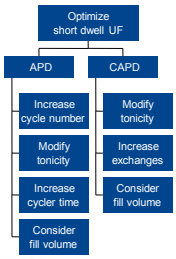


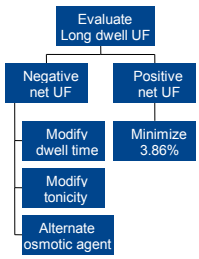
Abu-Alfa et al, Kidney Int (62), Suppl 81 (2002)

Logical approach to management of fluid balance

- Clinical assessment of fluid status is the first and most important step
- Has the patient lost RRF?
- Is the patient drinking excessively bearing in mind their combined output from RRF and peritoneal UF?
- Examine patient dialysis record to examine weight and glucose strength the patient is using
  - Long dwell?
  - Short dwell?
- Plan prescription change after assessment of when in the day the UF problem is developing AND important to know the membrane transport of the patient
  - Faster the transport – shorter short dwell is needed

Optimal Fluid Management: Algorithms for short and long dwells





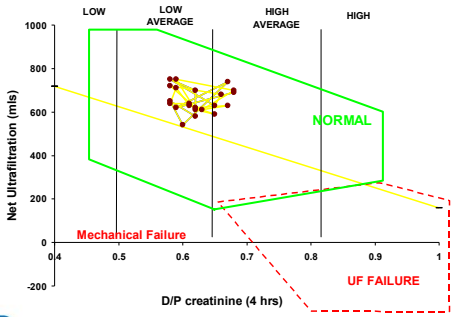
Abu-Alfa et al, Kidney Int (62), Suppl 81 (2002)

APD and fluid removal

- APD allows more frequent, shorter duration dwells which allows better fluid removal in faster transport patient
- The shorter cycled dwells are associated with greater UF because the osmotic gradient is not allowed to dissipate
- Getting the length of dwell right for the patient (knowing their membrane transport status) is important
- Extraneal can be used for the long dwell OR glucose with a mid day drain or exchange - this ensures there is good UF during the long dwell phase as well

Ultrafiltration Failure

- Can develop over time with PD and can be due to:
  - Development of faster transport
  - Progressive membrane damage with loss of aquaporin function (so loss of sodium sieving)
- Defined by PET test result
  - UF capacity with 2.27% < 200 mls at 4 hours
  - UF capacity with 3.86% < 400 mls at 4 hours
- Manage UF failure with the same prescription approaches as discussed but may result in need to transfer to HD
- This is the rationale for regular PET testing to assess D/P creatinine and UF capacity – to detect the changes in D/P and UF capacity



Conclusions

- **Fluid balance is one of the primary goals of renal replacement therapy.**
- PD is a continuous therapy and can help achieve this by avoiding large daily fluctuations
- Fluid management is based on:
  - Patient empowered to check fluid balance and record therapy details
  - Regular clinic assessment
  - Knowing the membrane transport status of the patient to allow logical PD prescription changes