Hemodialysis Vascular Access Modifies the Association between Dialysis Modality and Survival
Jeffrey Perl, Ron Wald, Philip McFarlane, Joanne M. Bargman, Edward Vonesh, Yingbo Na, S. Vanita Jassal and Louise Moist


Figure 1. Survival curves for HD-CVC (short-dashed line), HD-AVF/AVG (long-dashed line), and PD (solid line) demonstrate higher 1-year mortality in HD-CVC patients. (A) Unadjusted. (B) Adjusted on the basis of a stratified Cox proportional Hazards model stratified by HD-CVC, PD, and HD-AVF/AVG and adjusted for age, race, gender, era of dialysis initiation, end-stage renal disease comorbidity index, primary renal diagnosis, serum albumin, eGFR, province of treatment, and late referral.
Hemodialysis Vascular Access Modifies the Association between Dialysis Modality and Survival

More facts ...

- **Access-related problems** are responsible for ≥50% of the hospitalisations of HD patients.
- **HD**: 1 year AVF survival 83%.
- 1 year PD catheter survival 82%, 2 year survival 70%.
- **PD** Catheter survival of >80% at 1 year is a reasonable goal.
- Infection rate HD: 1 / 14 months – 1 / 55 months.
- Infection rate PD: 1 / 17 months – 1 / 60 months.
- Vascular access-related problems remain the Achilles heel of modern hemodialysis.
- Peritoneal access-related problems are a major reason for early drop out from PD.

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1. Vascular access: care and monitoring of function, R.Vanholder; NDT (2001) 16
3. Peritoneal catheter and access related practices toward optimum peritoneal access, 1998 update (ISPD)
4. A prospective study of vascular access infections at 7 outpatient HD centers, J.I.Tokars; Am.JKid Dis;37, No 6, 2001
Henry Tenckhoff (1968)

Catheters commonly used for peritoneal dialysis

Tenckhoff

Coiled catheter

Oreopoulos-Zellermann

Swan neck
Peritoneal dialysis catheter configurations
(no cuff, single-cuffed, double-cuffed)


Peritoneal dialysis catheter configurations
(no cuff, single-cuffed, double-cuffed)

Peritoneal dialysis catheter: technique survival

Tenckhoff catheter versus coiled catheter (evidence level A)

Akyol AM et al (Perit Dial Int 1990): no difference

Nielsen PK et al (Perit Dial Int 1995): 1 year catheter survival superior with coiled catheter (36% vs 77%)

Johnson DW et al (Am J Kidney Dis 2006): median technique survival superior with straight catheters (2.1 vs 1.5 years)

Tenckhoff catheter versus Swan neck catheter (evidence level A)

Eklund BH et al (Perit Dial Int 1994): no difference

Eklund BH et al (Perit Dial Int 1995): no difference

Lye WC et al (Perit Dial Int 1996): no difference

Single-cuff vs double-cuff catheter (Tenckhoff) (evidence level A)

Eklund B et al (Nephrol Dial Transplant 1997): no difference

PD catheter: implantation technique

Blind implantation (Seldinger technique)

**Pros:**
- Bed-side placement possible
- General anesthesia not required
- In some studies decreased risk of pericatheter leakage as compared to other techniques
- Optimal method in patients with ascites

**Cons:**
- Risk of bowel perforation (not recommended in obese patients, patients with adhesions or those with a history of extensive abdominal surgery)
- Other interventions (e.g. corrections of hernias) cannot be done simultaneously
- Exploration of the abdominal cavity not possible
**PD catheter: implantation technique**

**Endoscopic implantation (laparoscopy)**

**Pros:**
- Less invasive than surgical technique
- Can be done in general or local anesthesia
- Exploration of the abdominal cavity is possible
- Allows simultaneous interventions (e.g. adhesiolysis) to some extent

**Cons:**
- Larger surgical interventions cannot be done during the same session (especially when insertion is performed by a nephrologist)
- Technique requires more experience (laparoscopy) than other methods

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**PD catheter: implantation technique**

**Surgical implantation (laparotomy)**

**Pros:**
- Preferred technique in patients with bleeding disorders (or previous abdominal surgery)
- Preferred technique if other interventions (e.g. correction of hernias) are required

**Cons:**
- more invasive than other techniques
- Surgical team and (in most cases) general anesthesia is required
Peritoneal dialysis catheter implantation: what do guidelines say?

European Best Practice Guidelines, Nephrol Dial Transplant 20 (Suppl 9): ix8-ix12, 2005

- The experience of the team is more important than the type of catheter and the method of implantation (evidence level A)

- Catheters should preferably be implanted operatively or by laparoscopy, but the Seldinger technique in selected cases can achieve comparable outcomes (evidence level A-B)

- Catheter model may be important in special situations, e.g. presternal swan neck catheter in patients with colostomy/obesity

Implantation of the PD catheter: pre-operative management

EBPG, Nephrol Dial Transplant 20 (Suppl 9): ix8-ix12, 2005

- Examination of the abdominal wall (scars? hernias?)

- Pre-marking of the exit site (sitting position!) should be visible for the patient avoid the belt-line or fat folds

- Hernias should be corrected simultaneously with catheter implantation

- Patient should take a shower and empty his/her bladder before implantation

- Bowel preparation

- Antibiotic prophylaxis is recommended
Antibiotic prophylaxis before implantation of the peritoneal dialysis catheter


- **vancomycin** n=86
  - 1% peritonitis

- **cefazolin** n=85
  - 6% peritonitis

- **no prophylaxis** n=83
  - 12% peritonitis

p=0.02 vs other groups

Peritoneal dialysis catheter: implantation
Preferred localisation of the peritoneal dialysis catheter (double-cuff)

Swan neck presternal catheter
may be preferred in special situations, e.g. patients with obesity, stomas

D = distal tube; C = deep cuff (rectus muscle); F = flange; B = bead; T = titanium connector; P = proximal tube; m = medial (center) cuff; s = superficial cuff

The self locating PD catheter – less dislocation?

Figure 1 — The new self-locating peritoneal catheter.

Figure 1 — Lateral x-ray image of lower abdomen, showing correct position of the tip of the self-locating catheter.

THE SELF-LOCATING CATHETER: CLINICAL EXPERIENCE AND FOLLOW-UP
Perit Dial Int 24: 359-364, 2004


Figure 2 — Percentages of total, minor, and major dislocation in patients with Tenckhoff catheter (black bars) and self-locating catheter (grey bars) over a period of 24 months.

Figure 3 — Probability of survival of Tenckhoff (triangles) and self-locating (squares) catheters over 24 months, showing superiority of the latter.
**Subcutaneous embedding of the peritoneal catheter**
(the Moncrief-Popovich approach)


- a: external limb of the catheter is buried under the skin at the time of implantation
- b: external limb is exteriorized when dialysis is needed

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**Catheter embedding**

- No exposition of the catheter to the contaminating environment of the exit site.
- Better acceptance by the patient of an earlier implantation.
- No manipulation of the catheter until starting dialysis.
- Prevents emergency HD.
- Cost effective despite a second procedure (exteriorisation of the catheter).*
- Dialysis can be started with maximal dialysate volume without delay after exteriorisation.
- Better flexibility and less stress in OR management as there is no emergency.


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**Fistula concept applied to PD!**
"Break-in" period after implantation of the peritoneal dialysis catheter

EBPG, Nephrol Dial Transplant 20 (Suppl 9): ix8-ix12, 2005

Recommendations (evidence level C):

• Catheter insertion should be performed at least 2 weeks before starting PD

• no consensus if peritoneal washing (with or without heparine) during the "break-in" period (e.g. once/week) is necessary or not

• If an earlier start of PD (≤ 2 weeks) is necessary intermittent PD with low fill volume (1 L) should be preferred

Break-in period after catheter implantation:

Group 1 (n=32): hemodialysis for 2 weeks
Group 2 (n=74): intermittent peritoneal dialysis (fill volume 1 L) for 2 weeks


<table>
<thead>
<tr>
<th></th>
<th>Group 1</th>
<th>Group 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Catheter - associated infections</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>early (0-2 weeks)</td>
<td>6 (18.8%)</td>
<td>16 (21.6%)</td>
</tr>
<tr>
<td>late (&gt; 2 weeks - 3 months)</td>
<td>1 (3.1%)</td>
<td>3 (4%)</td>
</tr>
<tr>
<td><strong>Peritonitis</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>early (0-2 weeks)</td>
<td>0</td>
<td>9 (13%)</td>
</tr>
<tr>
<td>late (&gt; 2 weeks - 3 months)</td>
<td>8 (25.8%)</td>
<td>16 (23.2%)</td>
</tr>
<tr>
<td><strong>Leak</strong></td>
<td>1 (3.1%)</td>
<td>5 (6.8%)</td>
</tr>
<tr>
<td><strong>Catheter loss</strong></td>
<td>3 (9.7%)</td>
<td>5 (7.2%)</td>
</tr>
</tbody>
</table>
Postoperative management of the catheter exit site

EBPG. Nephrol Dial Transplant 20 (Suppl 9): ix8-ix12, 2005

Immediately after implantation (healing period)
• Dressing change ≥ 1x/week (evidence level C)
• Local care: NO consensus (but avoid povidone iodine and hydrogen peroxide for cleaning the early exit site because of cytotoxicity!)
• Immobilisation of the catheter (evidence level C)
• Avoid heavy lifting during the first 6-8 weeks

Chronic peritoneal dialysis patients
• If dressing is used: daily dressing change (avoid occlusive dressings)(evidence level C)
• Routine use of mupirocin oder gentamicin cream at the exit site is recommended to prevent exit site infections (evidence level A!)

Golden Rules of Catheter Implantation

• Assessing the optimal location for the exit site is essential (e.g. visible for the patient, no mechanical irritation)

• Experience of the surgeon/team is more important than implantation technique or choice of the catheter model

• Paramedian incision with trans-rectus dissection of the muscle is recommended

• Implantation at the left side is recommended (because it avoids the caecum)
Golden Rules of Catheter Implantation

• Closure of the peritoneum and the posterior rectus fascia around the catheter ("purse string" suture) is important to avoid leakages

• Incision at exit site using a scalpel should be avoided (tunnel should be constructed by passing a trocar from inside the wound out)

• Sutures at the exit site should be avoided (increased risk of infection and delayed wound healing)

• If double-cuff catheters are inserted the superficial cuff should be located at least 2 cm from the skin exit site (to avoid external cuff extrusion!)

Golden Rules of Catheter Implantation

• Exact implantation of swan neck catheters (arcuate course of the tunnel) but also of straight catheters (first deep part of the tunnel should be in vertical direction (to avoid catheter dislocation)

• A break-in period of at least 2 weeks between catheter insertion and start of PD is recommended to minimize the risk of dialysate leakages

• Preoperative antibiotic prophylaxis using a first generation cephalosporin or vancomycin is recommended

• Find a surgeon who is interested in this technique—or do it yourself!
Nephrology Core Curriculum Course: Peritoneal Dialysis

PD-related complications: 1. non infectious

Pr Max Dratwa  
Honorary Consultant, Nephrology-Dialysis  
*CHU Brugmann, ULB-VUB*  
*Brussels*

SBN-NVB  
Brussels, March 18, 2017
Objective

- Explain the different PD-related complications and their implication
- Broadly classified by their origin: infectious and non-infectious

Non-infectious complications of PD

- Catheter-related
  - Related to elevated abdominal pressure (IPP)
  - Degradation of peritoneal membrane
  - Related to the presence of PD fluid
Catheter-related

- Difficult inflow or outflow
  - Catheter migration
  - Catheter obstruction (clot - omental wrapping)
- Action
  - First, plain X Ray
  - Laxatives
  - Inject dialysate under pressure (never aspire!)
  - X Ray after injection of contrast
  - If no clue, laparoscopic exploration

<table>
<thead>
<tr>
<th>Cause</th>
<th>Mechanism</th>
<th>Early/Late</th>
<th>Infusion/Drain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constipation</td>
<td>KT adheres to bowel</td>
<td>both</td>
<td>Mostly drain</td>
</tr>
<tr>
<td>Adhesions &lt;Op</td>
<td>Wrapping of extremity</td>
<td>early</td>
<td>both</td>
</tr>
<tr>
<td>Adhesions &gt;Op</td>
<td>Wrapping of extremity</td>
<td>late</td>
<td>both</td>
</tr>
<tr>
<td>Migration → Diaphragm</td>
<td>constipation</td>
<td>both</td>
<td>drain</td>
</tr>
<tr>
<td>Kinks</td>
<td></td>
<td>both</td>
<td>Mostly drain</td>
</tr>
<tr>
<td>Blood</td>
<td>clots</td>
<td>early</td>
<td>both</td>
</tr>
<tr>
<td>Fibrin - Peritonitis</td>
<td>Fibrin clots or purulent fluid</td>
<td>late</td>
<td>both</td>
</tr>
</tbody>
</table>
Catheter-related

Catheter migration

Laxatives

Catheter-related

- Catheter obstruction: blood clot
Catheter-related

Catheter obstruction: fibrin clot

Vanderperren et al; Nephrol Dial Transplant 2002;17:2265-7

Catheter-related

Catheter obstruction: omental wrapping
Catheter-related

Drainage problems: Abdominal obesity

Catheter-related

« Personal shortening» of the catheter
Non-infectious complications of PD

• Catheter-related

• Related to elevated abdominal pressure
  • Degradation of peritoneal membrane
  • Related to the presence of PD fluid

Related to increased abdominal pressure

- Leaks
- Hydrothorax
- G-oes. reflux
- Appetite decrease
- Hernia
- Prolapsus
- Lumbar pain
- Access related complications
- Peritonitis
- Insufficient UF
Increased IPP

Normal IPP < 16 cm H₂O
- Depends on:
  - Volume infused + UF
  - Position (sitting > standing > lying)
  - Age
  - Body mass index
  - Certain activities: great effort, coughing, defecation (constipation!)
Related to high IPP

Respiratory:
- Alteration of respiratory function

Digestive:
- Pancreatitis
- Constipation
- Gastro-oesophageal reflux

Hernia: risk factors

- IPP too high
- Multiparity
- Age?
- Previous surgery
- Previous hernia
- Polycystic kidney disease
Umbilical hernia

Inguino-scrotal hernia

Tintillier M et al; Lancet 2003;362:1893
Hernia: attitude

- Assess and treat before starting PD
- Make sure reduction is possible
- Surgical repair always necessary
- Stop PD
- Reintroduce PD with low volumes, supine posture (APD), increase volume over 2 weeks

Leakage

- Pericatheter: most frequent, early, when early initiation; easy diagnosis thanks to the presence of glucose (Dextrostix)

- Genital

- Parietal $\rightarrow$ looks like ‘orange skin’ (sometimes in pt’s back!)
Leakage

• **Signs**: ↑ weight & ↓ expected drain volume (# UF failure)
• Associated with age and high BMI (Del Peso G et al PDI 2003; 23:249-54)

• **Attitude**: 
  – ↓ IPP (small volumes, APD)
  – Catheter replacement
  – Surgery

Peritoneo-pleural leak

Symptoms and signs:
• Those of pleural effusion (mostly on the right side)

Peritoneo-pleural leak

diagnostic
Thorax XRay
Pleurocentesis (comparison glucose levels pleural/blood) and drainage
Add Methylene Blue in dialysate before : NO! (painful)
Peritoneography (! Request Late Images)
- isotopic albumin*
- CT with contrast
causes
Direct communication (congenital holes)
Indirect communication via lymphatics

Peritoneo-pleural leak: management

- temporary transfer to HD
- small infusion volumes
- transfer to APD
- pleurodesis
  - tetracycline
  - blood (autologous)
  - glue
  - talc

Peritoneo-pleural and peritoneo-mediastinal leak


Non-infectious complications of PD

• Catheter-related
• Related to elevated abdominal pressure
  • Degradation of peritoneal membrane
  • Related to the presence of PD fluid
Changes in morphology of the peritoneal membrane

The Peritoneal Biopsy Registry®

Exposure to Glucose & peritoneal histology

Pearson correlation p<0.01 (n=70)
Spearman Rank Correlation p < 0.01 (n=70)
Encapsulating Peritoneal Sclerosis (EPS)

- Causes a picture of recurrent intestinal obstruction even after stopping PD in a patient treated since several years with PD + severe peritoneal infections + catheter removal

EPS

Attitude
- TPN during several months
- Adhesiolysis under coelioscopy
- Steroids
- ? Immunosuppression (role of transplantation)
- Tamoxifen (Nolvadex®: breast cancer) 200 mg bid
- ? Maybe keep the PD catheter in place

Bad Prognosis: 50% mortality within 1 year of diagnosis
Non-infectious complications of PD

• Catheter related
  • Related to elevated abdominal pressure
  • Degradation of peritoneal membrane (increased permeability)

• Related to the presence of PD fluid

Eosinophilic Peritonitis (rare)
Often during the first weeks

**Observation**
Cloudy effluent
no pain, no fever

**Attitude**
- Lab: cell count + formula!
- > 10% eosinophils
- no bacteria on Gram stain
- Negative Cultures
  No treatment!!
Dialysate as a diagnostic tool

Causes of bloody dialysate:
- retrograde menstruation
- ovulation (back thanks to PD)
- peritoneal endometriosis
- ectopic pregnancy
- ruptured cyst (ADPKD, ovary)
- cancer (ovary, colon, kidney)
- peritoneal carcinomatosis
- pancreatitis
- splenic laceration or rupture
- EPS
- intra-abdominal «catastrophy»
Dialysate as a diagnostic tool

Approach to hemoperitoneum:
- Patient and staff reassurance
- Cytologic analysis; Hct: 0.3%
- Heparin IP 500-1000 U/2L dwell to prevent clot formation and catheter obstruction
- Fast lavages using unwarmed, room temp dialysate (vasoconstriction)

Causes of chyloperitoneum
- Non-lymphoma abdominal malignancy
- Lymphoma
- S/p PD catheter insertion
  - Cholecystectomy
  - AAA repair
- Cirrhosis
- Pancreatitis
- Amyloidosis
- Superior vena cava syndrome
- Calcium channel blocker medic.
The same with UV light

After fluorography

Dialysate as a diagnostic tool

Courtesy E. Goffin
PD-related complications: 2. infectious

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Brussels

Outline of presentation

• Prevention of PD related infections
  – Early care
  – Training
  – Prevention of exit site infections
  – Prevention of peritonitis
• Approach to ESI/tunnel infections
• Approach to peritonitis
• Components of CQI
PD related infections:

- ESI
- Tunnel infections
- Peritonitis

- ANY PD RELATED INFECTION IS A MEDICAL EMERGENCY – must not be left untreated
- Prevention is a key element of every succesful PD program

PREVENTION STARTS ALREADY PRIOR TO CATHETER INSERTION

- Nose swab to identify SA carriers (patients and partners/caregivers)
- Constipation resolved
- Proper location of future ES, identification of repairable hernias/gallstones
- Prophylactic antib (1st gen cef., vanc. possibly superior)
- Best technique of catheter implantation:
  - Perfect hemostasis, no sutures at ES, ES facing downwards (or laterally)
  - 2-cuff catheter better than single cuff
- After insertion:
  - Trained nurse, sterile technique, no dressing removal for 5-7 days (if dry)
  - No showers/bath to ES until well healed (2-3 weeks)
  - Good immobilisation of catheter
The training:

• The trainer is trained
• Well prepared curriculum and protocols for training and training visits
• Patient is tested at the end
• Refer to:


Obligate (re)training contents for infection prevention

• Hand hygiene and disinfection
• Proper technique of exchanges
• Proper exit-site care
• Proper response to contamination
  – Center protocol needed:
    • Tubing change
    • Prophylactic antibiotic (single dose/2 day course)
• Recognition of signs/symptoms of peritonitis
Should the patients be re-trained?

After 33 months on PD:
- 34% of patients did not answer the questionnaire accurately
- 23% did not follow the correct exchange procedures

0
3
1
2
1
2
1
2

Retrain the patient

Suggestions for Retraining Frequency

After hospitalization
After peritonitis or catheter infection
After change in dexterity, vision, or mental acuity
Three months after initial training and routinely thereafter
(once yearly at minimum)

Prevention of ESI

- Daily application of mupirocin to ES reduced SA ESI and SA peritonitis in numerous studies
- Recommendation: all PD patients should use topical antibiotic at ES or/and intranasally
- Mupirocin widely used but:
  - Problem of resistance
  - Mupirocin vs. gentamicin: JASN 2005

![Prevention of ESI](image)

Prevention of ESI

Problem: increased risk of fungal ESI with gentamicin

ESI and tunnel infection vs catheter infection

• ESI DEFINED
  – PURULENT DRAINAGE
  – WITH/OUT ERYTHEMA
    • Full blown picture may be present: “tumor, dolor, calor, rubor”
    – Isolated positive culture is not ESI (colonization)
    – Erythema without drainage – may not always be infection

• TUNNEL and CUFF infection
  – are usually joined with ESI
  – But may occur alone, may be occult
  – Beware SA, PsA – progression to peritonitis!

Exit site scoring system

Diagnosis of exit site infection if score ≥ 4 and/or purulent drainage

<table>
<thead>
<tr>
<th></th>
<th>0 point</th>
<th>1 point</th>
<th>2 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swelling</td>
<td>no</td>
<td>exit only; &lt;0.5 cm</td>
<td>&gt; 0.5 cm and/or tunnel</td>
</tr>
<tr>
<td>Crust</td>
<td>no</td>
<td>&lt; 0.5 cm</td>
<td>&gt; 0.5 cm</td>
</tr>
<tr>
<td>Redness</td>
<td>no</td>
<td>&lt; 0.5 cm</td>
<td>&gt; 0.5 cm</td>
</tr>
<tr>
<td>Pain</td>
<td>no</td>
<td>slight</td>
<td>severe</td>
</tr>
<tr>
<td>Drainage</td>
<td>no</td>
<td>serous</td>
<td>purulent</td>
</tr>
</tbody>
</table>
Clinical symptoms of peritonitis

- Cloudy dialysate 95-100%
- Abdominal pain (variable intensity) 70-95%
- Fever 20-80%
- Nausea, vomiting 20-80%
- Weight gain 25-75%
  (ultrafiltration failure type 1)
- Diarrhea 5-15%
- Constipation, paralytic ileus 1%
Practical definition of PD peritonitis

Presence of two of the following three criteria:

1. Cloudy dialysate: dialysate leukocytes > 100/µl, > 50% polymorphonuclear cells
2. Clinical symptoms of peritonitis (abdominal pain, fever, vomiting)
3. Presence of organisms on Gram stain or subsequent culture of dialysate

In equivocal cases (e.g. empty peritoneal cavity):
Intraperitoneal infusion of 1 L dialysate for 2 hours: leukocyte count

If diagnosis remains unclear:
Perform a second exchange with a dwell time of 2 hours and repeat dialysate leukocyte count

Causative organisms of PD-peritonitis

Gram-positive:
- Coagulase-neg. staphylococcus 30-40%
- Staphylococcus aureus 20%
- Streptococcus sp. 10-15%
- Enterococcus 3-6%

Gram-negative:
- Escherichia coli 5-10%
- Pseudomonas sp. 3-10%
- Proteus sp. 3-6%
- Acinetobacter sp. 2-5%
- Klebsiella sp. 1-3%

Anaerobic organisms 2-5%
Fungi 2-10%
Others 2-5%
Culture negative 0-20%
Reasons for Culture negative

- No sample sent
- Sample sent after antibiotics commenced or patients taking anyway
- Laboratory handling
- Unusual fastidious organisms
- Fungus/ TB
- Sterile
  - No signs of bacterial infection
  - Resolves without antibiotics

CATHETER INFECTION
CULTURE GRAM STAIN

EMPIRIC AB SHOULD COVER SA
Cephalexin 500 bid
Fluclox 500 qds
(ciprofloxacin 250 bid
If PsA Hx and PsA sens.,
Vanc. if MRSA possible)

G+: penicillinase res.
penicillin OR
1st gen cephalosporin
SA: add rifampicin if slow healing.

G-: PO
fluoroquinolones
2 antibiotics for PsA
(fluoroquinolone + ip
cefazidime, gentamicin, cefepime, imipenem)

No copious discharge
No pain
No edema
No tunnel/cuff infec.

Intensified local care
Local antibiotic

Resolving: min 2 weeks th AND until the ES appears normal
Non-resolving: cath /ex or replac. after 3-4 weeks
(possibility of exteriorisation and shaving of the outer cuff)

Resolving: min 2 (3 for PsA) weeks th AND the ES appears normal
Non-resolving: cath /ex or replac. after 3-4 weeks
Remember 123

1 Pseudomonas  
2 Antibiotics  
3 Weeks

And is similar for SA - rifampicin 2nd drug

ULTRASONOGRAPHY

- 1 mm fluid after 2 weeks of antibiotic at external cuff and/or tunnel: poor prognosis
- Relapse, peritonitis
Table 5. Sonographic follow-up of peritoneal dialysis patients with deep tunnel infections

<table>
<thead>
<tr>
<th>Group</th>
<th>Fluid Around Cuff (mm)</th>
<th>Initial</th>
<th>After 1 Week</th>
<th>After 2 Weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catheter lost</td>
<td>5.49 ± 0.58</td>
<td>5.34 ± 0.49</td>
<td>5.06 ± 0.38b</td>
<td></td>
</tr>
<tr>
<td>Catheter saved</td>
<td>7.02 ± 0.70c</td>
<td>6.48 ± 1.05</td>
<td>3.75 ± 1.04hc</td>
<td></td>
</tr>
</tbody>
</table>

*Cases with simultaneous peritonitis are not included.

b Improvement after 2 wk: Patients who lost their catheter ("catheter lost") versus patients who did not require catheter removal ("catheter saved"); \( P < 0.02 \).

c Fluid around the cuff before versus 2 wk after initiation of therapy; \( P < 0.002 \).


Remember

US finding: any new pericatheter fluid collection in SA and PsA ESI is tunnel infection
Management of peritonitis

• Cloudy effluent – peritonitis until proven otherwise
  – The DD of cloudy effluent…

• PD patient with abdominal pain – always exclude peritonitis
  – Intense abd. pain (Streptococcus, G-ve rods, SA)

• Do not delay antibiotic Th as per protocol

DD of cloudy effluent

Specimen from dry abdomen
• It clears within 1-2 cycles, majority of cells are mononuclears

Chemical peritonitis
• Usually no fever, culture neg., causative agent

Eosinophilia of the effluent
• >10% eosinophils, most cases early after cath. insertion, reaction to cath. or dialysate, self-limited

Hemoperitoneum
• At menstruation, ovulation, add 500 IU heparin/L in simple cases

Malignancy
• Symptoms of mlgnt disease present, send for cytology

Chylosus effluent
• Neg. cultures, cloudy-white, normal cell counts or elevated lymphocytes, high TG
Peritonitis

- Cloudy effluent
- Symptoms
  - >100 WBC/µl after a dwell of at least 2h
    • > 50% polymorphonuclear neutrophils

- ACT immediately:
  - Cell count with differential, gram stain (may show fungus or polymicrobial flora), culture*
  - Consider Heparin 500 u/L and 1-2 rapid exchanges for very turbid effluent
  - Antibiotics as per protocol
    • G+ve coverage (Ceph 1st gen/Vanc)
    • G-ve coverage (Ceph 3rd gen/aminoglycoside)
    • IP dosing is preferrable
    • Allow min. 6-hour dwell for antibiotic absorption

*optimal culture is combination of 50 ml sediment culturing and effluent inoculation in two blood-culture bottles

Where to look for guidance and antibiotic dosages

ISPD GUIDELINES/RECOMMENDATIONS
Perit Dial Int 2016; 36: 481-508

ISPD PERITONITIS RECOMMENDATIONS:
2016 UPDATE ON PREVENTION AND TREATMENT
Philip Kam-Tao Li, Cheuk Chun Szeto, Beth Piraino, Javier de Arteaga, Stanley Fan, Ana E. Figueiredo, Douglas N. Fish, Eric Goffin, Yong-Lim Kim, William Salzer, Dirk G. Struijk, Isaac Teitelbaum, and David W. Johnson
Where to look for antibiotic stability in PD bags

**Ask/examine patient**

- A break in technique?
  - Contamination, disconnection
- Constipation/diarrhea?
- ESI/tunnel infection?
  - Always inspect, culture drainage if any
- Could this be a relapse?
- Recent invasive procedures?
- Abdominal cause?
  - Localised pain/tenderness

**What’s the bacteria?**

<table>
<thead>
<tr>
<th>Bacteria</th>
<th>Etiology</th>
</tr>
</thead>
<tbody>
<tr>
<td>CoNS (Staph. ep.&amp;others)</td>
<td>Touch contamination/ESI (if relapse CONS – biofilm – replace cath.)</td>
</tr>
<tr>
<td>Corynebacterium Polymicrobial G+ves</td>
<td></td>
</tr>
<tr>
<td>Enterococcus</td>
<td>Intraabdominal pathology possible/ also touch /catheter</td>
</tr>
<tr>
<td>Streptococcus</td>
<td>Mouth (hygiene, procedure)</td>
</tr>
<tr>
<td>SA</td>
<td>Touch/Catheter infection/Nose</td>
</tr>
<tr>
<td>PsA</td>
<td>Often cath. Infection – remove cath</td>
</tr>
<tr>
<td>Single G-ve</td>
<td>Constipation/diverticulitis/colitis, (but ESI, touch possible)</td>
</tr>
<tr>
<td>Polymicrobial (G-ve/G-ve and G+ve)</td>
<td>Abdominal sources – surgical peritonitis – CT scan + surgical exploration</td>
</tr>
</tbody>
</table>
Major time points

1st day
- G stain, culture, effluent cell count
- Protocol
- Search for etiology

2-3rd day
- Isolates and sensitivities
- Think about the cause

3rd day
- Effluent count (<1090 wbc?) & improvement?
- Repeat culture if not improving
- May use antibiotic removal techniques

5th day
- If refractor y – remove catheter
- Latest time to check for the level of Vanc

2
- May discontinue antibiotic in well responding G+ve cases with cleared effluent and uncomplicated course

3
- Min. time of treatment for SA, Enterococcus, PsA

If catheter not removed in SA, Enterococcus, PsA – treat with 2 antibiotics, at least 3 weeks, Stenotrophomonas – similar to PsA: 2 antibiotics, therapy for 3-4 weeks

Indications for catheter removal

- Refractory peritonitis/refractory ESI/tunnel infection
- Relapsing peritonitis
- Fungal peritonitis
- Strongly consider in
  - Repeat peritonitis
  - Mycobacterial peritonitis
  - Multiple enteric organisms – abdominal pathology
constant quality improvement...

- Compare with previous data, other units, national average
- Decide on which areas there is the largest need for improvement
- Include nurses and other team members in decision-making process

ACT

- Plan protocol modifications
- Training of personnel and patients
- Equipment changes

PLAN

- Implement the changes
- Educate, train, inform

CHECK

- Monitor infection rates
- Patient satisfaction
- Personnel satisfaction
- Costs

DO

What can be monitored

- Incidence of peritonitis
- Pattern of infection
  - Presumed etiologies
  - peritonitis in hospitalised pts,
  - time from symptom onset to presentation,
  - proportion of culture neg. peritonitis

- Causative organisms
- Antibiotic sensitivities
Conclusions – what did I say

- Principles of prevention
  - Training, retraining, ES care, peritonitis
- Approach to catheter infection
- Encouragement to US use
- Approach to peritonitis
  - Diagnosis, etiology – root cause, principles of therapy
- How to improve the care - CQI

Risk factors for poor peritonitis outcome

- Low residual GFR
  - Perez fontan PDI 2005
  - Perhaps due to inadequacy, malnutrition, volume overload
- Concurrent ESI/tunnel infection
- Peritoneal dialysate effluent total wcc/mm3:
  - >1090 at day 3, >500 at day 4, >100 for at least 5 days
- Microbiology
  - G-ves worse outcome than G+ves (except SA)
  - Fungi, polymicrobial, Mycobacteria – poor outcome
- In case of culture negative peritonitis:
  - Recent (within 30 days) antibiotic therapy doubles the risk for primary non-response (OR2.12)
  - Recent (within 120 days) peritonitis predicts failure of complete cure (without cath. Extirpation and relapse in 120 days, OR2.87)
- Beware of recurrent peritonitis
  - It has lower primary response rate, complete cure (only 42%) and higher mortality (up to 21%) as compared to relapsed or control peritonitis
  - Caused by G-ves and polymicrobial growth
Prevention of peritonitis – modifiable factors

PREPROCEDURAL MEASURES (prophylactic antibiotic, empty adomen)

BOWEL (constipation, diarrhea/colitis, diet in diverticulosis)

METABOLISM (potassium, nutrition/hypoalbuminemia, active vit. D)

FUNGI (prophylaxis with prolonged antibiotic th)

ENVIRONMENT (pets, airborne dust, general hygiene – home visit)

DEPRESSION (risk factor)

Bad things after technique failure: recurrent ascites, EPS, death

• Moon SJ, PDI 2008; 28: 352.
  – Effluent wcc at 72h predicts ascites
  – CRP at 72h and PD vintage predicted EPS (240 mg/l vs. 78 mg/l controls)
  – CRP at 72h and age predicted death (240 mg/dl vs. 174 mg/dl at baseline in the death group)

• Peritonitis-related death definitions vary:
  - death due to sepsis from peritonitis, death with a positive effluent culture, death in hospitalisation due to peritonitis or in the 14 days since peritonitis start
  - any death in 30 days after peritonitis (Boudeville jasn 2012).
Possible Consequences of PD-related Peritonitis

- Temporary loss of UF (good indication for Extraneal)
- Increased protein losses (indication for Nutrineal?)
- Catheter loss
- Adhesions
- Encapsulating peritoneal sclerosis
- Transfer to HD
- Death

Conclusions

Keys to low infection rates include:

- Experienced personnel and careful training
- Minimize use of manual spike systems
- Continuous monitoring of infection rates and organisms
- Protocols for prevention, such as exit site mupirocin for *S. aureus* and now gentamicin cream

*Most infectious complications = Predictable and Preventable*
What are the goals?

- Peritonitis rate below 0.67/year at risk
  - Less than 1 episode in 18 pt-months
  - Rates below 0.29 (1/41 pt-m) are achievable

- SA targets
  - Catheter infection < 0.05 episode/year (1 in 240 months)
  - Peritonitis < 0.06 episode/year (1 in 200 months)

Obviously there are many different ways to reach the goal, but if

- your peritonitis rate is equal or better than 1 episode/24 patient months
- the percentage of negative cultures in case of cloudy effluent is < 20%
- your cure rate of peritonitis is > 80%
- you do not have serious resistance problems

you probably have found a GOOD way!
1 patient / 2 escapes the risk of having peritonitis within 31-34 months
Nephrology Core Curriculum Course: Peritoneal Dialysis

PD prescribing for all

Pr Max Dratwa
Honorary consultant, Nephrology-Dialysis
CHU Brugmann, ULB – VUB
Brussels

QUESTION: Which approach? “One size fits all” or haute couture? (1) or (2)?
The patient

- Young (61) man,
- ADPKD
- Still working as an accountant (mostly at home)
- Candidate for cadaveric kidney transplantation
- BW: 62.2 kg
- eGFR 14 ml/min/1.73m² decreasing by 1/month
- BP controlled with ACE-inhibitor and furosemide
- Coiled swan-neck catheter inserted (Moncrief) after informed choice
- Some symptoms (more cramps, tiredness) when eGFR at 10
- Dialysis started when eGFR* at 8 (itching, decreasing appetite)
- Urine volume: 1.3 L with p.o. furosemide 125 mg/day

*: once the patient starts peritoneal dialysis, eGFR cannot be used to represent the contribution of RRF in calculations of clearance measurements

What do we want most for our patient?

- Control of uraemia (volume, small solutes, acid-base, kalaemia, anaemia, …)
- Good metabolic and nutritional status
- Maintenance of well functioning dialyser (Peritoneal Membrane)
- Maintenance of RRF for as long as possible
- Ability to work or study or « function »
- Sense of well-being
European Best Practice Guidelines (Nephrol Dial Transplant 2005; 20 Suppl 9)

• Fluid removal (urine + peritoneal UF) \( \geq 1 \) L/day

AND

• Small solute clearances: \( \text{Kt/V}_\text{urea} \geq 1.7/\text{week} \)
  (in slow transporters, mostly on APD, creatinine clearance > 45L/week/1.73 m²)

---

**ADEMEX: Primary Outcome**

ITT Patient Survival Comparing Treatment Groups

Log-rank Test: Chi-square = 0.0004, p-value 0.9842

(Control Group: Events/No. Pts = 157/484, Treatment Group: Events/No. Pts = 159/481)

- Control
- Treated

\( p=0.9842 \)

RR (Treated: Control) = 1.00

95% CI: (0.80, 1.24)
ACHIEVING ADEQUATE FLUID BALANCE

• Maintaining adequate fluid status is critical and patients with a fluid removal (combined peritoneal and renal) of less than 1L/day need assessment and possible changes in PD prescription.¹
• Use the patients hand held record for each CAPD exchange or the output of the APD cycler (initial drain from daytime dwell and total night-time UF) as well as weight and urine output.
• Remember that CAPD bags are overfilled by up to 200mL during manufacturing, therefore careful clinical assessment is key.
• This approach determines where the overhydration problem lies: drop in urine output? Low UF in short dwells? Low UF in long dwells?


ACHIEVING ADEQUATE FLUID BALANCE

• Generally you should avoid any exchange that results in fluid reabsorption while at the same time avoiding using high glucose concentration dwells regularly.
• Shortening dwell times can result in increased ultrafiltration, especially in patients with high transport characteristics (e.g. reduce long day APD dwell to 8-10 hours).
• 7.5% Icodextrin should be considered in patients with fluid overload related to insufficient UF in long dwells (APD & CAPD) and to avoid excessive glucose exposure.¹

The peritoneal equilibration test (PET)

Drain volumes correlate positively with dialysate glucose and negatively with D/P creatinine at 4 hours.

Data from Twardowski, TJ, Blood Purif 1988; 7:95.

Length of dwells and UF

Physiology of ultrafiltration showing net ultrafiltration with 1.36% glucose fluid. Shortening the dwell time could stop negative UF.¹

Physiology of ultrafiltration showing that with icodextrin this is prolonged and independent of membrane transport status.¹

QUESTION:
Which information do we **need** to write the **first** prescription?

- 1: A. Body size
- 2: B. Residual renal function (U volume/clearances)
- 3: C. Peritoneal membrane characteristics
- 4: A, B and C
- 5: A and B
- 6: B and C
ACHIEVING MINIMUM RECOMMENDED SMALL SOLUTE CLEARANCES

If measured small solute clearance is less than desired or predicted from a recent prescription change, it is recommended you ensure the 24-Hr dialysate and urine collections were done properly prior to changing a prescription.

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

<table>
<thead>
<tr>
<th></th>
<th>L (D/P &lt;0.5)</th>
<th>LA (D/P 0.5-0.65)</th>
<th>HA (D/P 0.65-0.81)</th>
<th>H (D/P &gt; 0.81)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small (&lt;1.71 BSA)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium (1.71-2.0 BSA)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large (&gt;2.0 BSA)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

What about lifestyle?

• To decide either CAPD or APD
• This should probably have been discussed beforehand
• Also important to decide about assistance (by nurse or family): role of previous home visit
Therapy Optimisation

CAPD

- Increase fill volume (start during night time dwell due to supine position)
- For patients without residual renal function, large BSA, or high transport type, a fifth exchange may be helpful (monitor for adherence and quality of life)
- Higher transport patients require icodextrin to sustain UF during long dwell or 2 short daytime glucose dwells of 4-6 hours
- Higher transport patients will 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 a daytime exchange (4-6pm) is an efficient way to increase clearance
- Higher transport patients require icodextrin to sustain UF during long dwell or 2 short daytime glucose dwells of 4-6 hours

A variety of APD regimes are possible depending upon whether there is PD fluid during the day (wet vs dry) and the number and length of daytime dwells.

Particularly advantageous are:

- Tidal PD - partial drain and fills during the night cycles - particularly useful for patients with pain at the end of the drain or in those with mechanical catheter problems.
- NIPD - Nocturnal Intermittent Peritoneal Dialysis: empty peritoneal cavity during the day (“dry day”) - can be useful at the start of PD when there is significant residual renal function or in patients with a leak or hernia.
- IPD
- CCPD
- OCPD
- CAPD - Cyclic Peritoneal Dialysis: one of more extra day exchanges (“high dose” APD) - can be used for patients requiring significant peritoneal small solute clearance e.g. anuric patients, very large patients
INDIVIDUALISING THE THERAPY

CLINICAL REVIEW VISIT

Evaluate the adequacy of the prescription for the patient

Clinical assessment
- Comorbid disease
- Nausea, vomiting, fatigue
- Nutritional assessment: appetite, signs of protein-energy malnutrition
- Exit site examination
- Quality of Life (social, psychological, professional, vitality)
- Medication review

Laboratory Assessment
- Urea, creatinine, K, Na, Cl
- Calcium, phosphorus, albumin
- Lipids, glycemic control

Membrane Assessment
- PET – at first review and then as indicated

Small Solute Clearance
- Kt/V, creatinine clearance

Fluid removal and volume status
- Presence of edema
- BP and weight
- Residual Renal Function
- Salt and fluid intake
- Treatment records (UF and Glucose)
- Compliance
- Check catheter function
- Check delivery records

Kt/V ≥ 1.7
Adequate Fluid Status

Kt/V < 1.7
Fluid Overload

Assess for uremic signs/symptoms or malnutrition

Kt/V ≥ 1.7
Adequate Fluid Status

Kt/V < 1.7
Fluid Overload

Kt/V < 1.7
Adequate Fluid Status

Kt/V > 1.7
Fluid Overload

Clinical assessment satisfactory

Clinical assessment suggests inadequate small solute clearance (even if Kt/V > 1.7)

Inadequate UF in long dwells

Use Icodextrin

Shorten dwell time if glucose used

Increase glucose concentration

Inadequate UF in short dwells

CAPD

APD

Check delivery records

CAPD

APD

Consider APD

Increase number of exchanges

Increase fill volume

Increase glucose conc.
What are our patient’s data when starting PD?

- Body size (height and weight)
  → Tables for BSA (to normalise his Ccr) based on height and body weight
  → Calculation of V (to calculate $Kt/V_{\text{urea}}$) based on the same (+ age if male in Watson formula)

- Residual renal function expressed as weekly Ccr (creatinine clearance: mean of creatinine + urea clearances) and/or as $Kt/V_{\text{urea}}$

NB: $1 \text{ ml/min/1.73m}^2 = 10 \text{ L/week/1.73m}^2$

--

Body Surface Area = $0.007184 \times (\text{Patient's Height, cm})^{0.725} \times (\text{Patient's Weight, kg})^{0.425}$

The patient

- BW: 62.2 kg
- Height: 175 cm
- BSA: 1.76 m²
- V: 30.99 L (by Hume formula but 36.1 if calculated by using 58% of BW)
- Weekly Kt/V urea: 2.0

(Baxter) PD solutions composition

<table>
<thead>
<tr>
<th>Electrolytes (mmol/l)</th>
<th>Dianeal PD1</th>
<th>Dianeal PD4</th>
<th>Physioneal 35</th>
<th>Physioneal 40</th>
<th>Extraneal</th>
<th>Nutrineal</th>
<th>Plasma (Adult)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium</td>
<td>132</td>
<td>132</td>
<td>132</td>
<td>132</td>
<td>133</td>
<td>132</td>
<td>136-145</td>
</tr>
<tr>
<td>Calcium</td>
<td>1.75</td>
<td>1.25</td>
<td>1.75</td>
<td>1.25</td>
<td>1.75</td>
<td>1.25</td>
<td>1.12-1.32</td>
</tr>
<tr>
<td>Magnesium</td>
<td>0.75</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.65-1.05</td>
</tr>
<tr>
<td>Chloride</td>
<td>102</td>
<td>95</td>
<td>101</td>
<td>95</td>
<td>96</td>
<td>105</td>
<td>98-107</td>
</tr>
</tbody>
</table>

| Buffer (mmol/l) |  |  |  |  |  |  |  |
|-----------------|  |  |  |  |  |  |  |
| Lactate         | 35 | 40 | 10 | 15 | 40 | 40 | 0.5-2.2 v ; 0.5-1.6 a |
| Bicarbonate     | 25 | 25 | 22-29 v ; 21-28 a |

| pH               | 5.5 | 5.5 | 7.4 | 7.4 | 5.5 | 6.7 | 7.4 |

<table>
<thead>
<tr>
<th>Osmotic agent, osmolarity (mOsm/l)</th>
<th>280-300</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.36% glucose</td>
<td>347</td>
</tr>
<tr>
<td>2.27% glucose</td>
<td>398</td>
</tr>
<tr>
<td>3.86% glucose</td>
<td>486</td>
</tr>
<tr>
<td>7.5% icodextrine</td>
<td></td>
</tr>
<tr>
<td>1.1% amino acids</td>
<td></td>
</tr>
</tbody>
</table>

*Tietz’s Clinical Guide to Laboratory Tests. (Conversion of Ca and Mg: 1 mmol/l = 2 mEq/l; conversion of Lactate: 1 mmol/l = 9 mg/dl) Sept 29, 2003, JT
NUTRINEAL: characteristics

- Osmotic agent: mixture of essential and non-essential AA (1.1%)
- Osmolality: 342 mOsm/kg H2O
- Buffer: lactate
- pH: 6.2
- Ca: 1.25 mMol/L
- UF and clearances: quasi ~ to Glucose 1.36%
- Good biocompatibility according to animal in vivo studies: → few morphologic modifications
- Supplies 25% of target protein needs WITHOUT phosphate and ↑ protein synthesis

NUTRINEAL: Indications

- Compensation of proteins and AA losses:
  most PD patients (especially fast transporters) + nephrotic patients with particular attention for diabetics + during or just after peritoneal infection (or other debilitating event)
- Patients at risk of malnutrition (rather than malnourished): "inflammatory" patients (fast transporters) + those in whom intake seems insufficient (patients already)

...for all patients in a strategy of glucose sparing, biocompatibility and of malnutrition prevention!
**NUTRINEAL : words of caution!**

- Not more than 1 bag per day
- Dwell of at least 5 H for max. absorption (80%)
- Administer with caloric source to prevent risk of ↑ urea level (benefit of mixing with glucose solution by cycler on APD : “dialysate as food”)
- Monitor bicarbonate levels [no problem if combined with 40 mmol/L buffer (Dianeal PD4 or Physioneal 40) and/or CaCO3 or R/ N HCO3]

**EXTRANEAL : characteristics**

- Osmotic agent : 7.5% icodextrin (glucose polymer)
- High MW → UF through colloïd osmosis via small pores
- Osmolality : 284 mOsm/kg H2O
- Buffer : lactate
- pH : 5.8
- Ca : 1.75 mMol/L
- Better UF compared to G 1.36% et 2.27%, ~ à 3.86% for 8H dwells but better if ≥12H
- Higher clearances thanks to better UF
- Absorption via peritoneal lymphatics (~40% in 12H)
- Metabolisation into polyoses (maltose, maltotriose...).
**EXTRANEAL**: *Indications*

- In order to avoid the use of “high glucose” solutions in all patients
- Good UF for “long dwells” → ideal for CAPD at night and APD during the day, especially for patients with low UF
- To maintain a positive UF during peritonitis
- In order to maximise UF and clearances while decreasing carbohydrate absorption
- To improve efficiency of a High Dose/OCPD regimen
- Also interesting for peritoneal UF in congestive heart failure

In summary, could be used in all patients!

---

**Physioneal 40/35: characteristics**

In Physioneal, glucose and buffer are in 2 distinct compartments:

The **top** compartment has a low pH that allows a reduction in GDP levels. Ca$^{2+}$ and Mg$^{2+}$ are separated from the buffer during sterilisation for stability questions.

The **bottom** one as a higher pH (7.5) and contains bicarbonate (25 mMol/L) and lactate (15 or 10 mMol/L).

Thus, still contains glucose, with similar concentrations and thus same osmolalities as in Dianeal, but with a different buffer (**bicar 25/lactate 15 or 10**), a [Ca] of **1.25 or 1.75** mMol/L and a pH of **7.4** after mixing.
**Physioneal: summary**

- Reflects physiologic levels of blood HCO₃ and pH.
- Leads to an equilibrated formulation of HCO₃, pCO₂, and lactate → **good correction of acidosis** (but no better than Dianeal PD4)
- Clearances ~ Dianeal (with better UF of ±150mL/d ?)
- Respects the natural environment of peritoneal cells (↑CA 125 and ↓ hyaluronic acid)
- Shows better biocompatibility in *in vitro* and *ex vivo* studies (EPDSR: ↓ incidence and duration of peritonitis ?)
- Decreases significantly pain on infusion when compared to conventional lactate solutions and to those with pure bicarbonate
- BUT Physioneal 40 may overcorrect acidosis and induce alkalosis and hypocalcemia in some patients (especially elderly, frail and/or on APD with large dialysate volumes)
- Manipulation a bit more difficult (mostly on APD, but there are 5 L bags)

**Physioneal: indications**

- **Possibly base solution for all pts**
  
  Especially, if pain on infusion
  - if marked acidosis
  - if long term PD projected
  - if already on PD for a long period
  - for APD (volumes >> CAPD)

- Choose 40 or 35 according to needs (acidosis ±, calcium ±)
The initial prescription

- Type of PD: CAPD
- Number and volume of exchanges: 3 x 2L
- Type of solutions: 2 x 1.36% Physioneal 40 during the day and 1 Extraneal for 9 to 12 hrs at night

**QUESTION:** Which information shall we need to write the “final” prescription?

- A. Body size
- B. Residual renal function
- C. Peritoneal membrane characteristics
- D. Intra abdominal/peritoneal pressure (IPP)
- E. The “adequacy” of the initial prescription
Assessment after 10-14 days

- Patient feels well, eats better
- BP normal
- Urine volume still 1.3 L and UF 0.2L (0.5 L with Extraneal over a 10 hrs dwell but – 0.3 L with the 2 Physioneal exchanges : 6 and 8 hrs dwells)
- $\text{Kt/V}_{\text{urea}} : 2.7/\text{week}$ (2.0 renal and 0.7 peritoneal)
- $\text{Ccr} : 122 \text{ L/week/1.73 m}^2$

QUESTION:
Are we satisfied?

- 1: Yes
- 2: No

We should repeat this assessment after 4-6 weeks and thereafter every 2 to 6 months or if clinically indicated
QUESTION:
Will we need some more information?
• 1: Yes
• 2: No

YES we need:
• Peritoneal membrane transport features:
  PET
• IPP

PETs
• Classic with 2.27% Glucose
• Derived from the Standard Peritoneal Permeability Analysis (Smit W et al. PDI 2000) with 3.86% G and measurements of D/P Na at 60 min. to evaluate aquaporins
• Short PET (2 hr instead of 4) with 2.27% G
• Mini-PET (1 hr instead of 4) with 3.86% G
About the short and mini-PETs

• Studies of short PET in adults (Twardowski ZJ et al. Adv Perit Dial 2003) and in children (Warady BA et al Perit dial Int 2007 and Cuevas M et al Pediatr Nephrol 2008) tend to show results similar to those of the classic PET

• Study of the mini-PET in adults (La Milia V et al. Kidney Int 2005; 68: 840-6) allows to calculate free water transport through the aquaporins as well as UF through the small pores

Our patient’s result for creatinine kinetics in PET
Mean IPP \(\frac{(IPP_{insp} + IPP_{exp})}{2}\) = 13 ± 2 cm H2O for a drained vol. of 2820 ± 419 ml
18 patients
Maximal exp IPP 20 cm H2O
Not predictive of mechanical complications

Mean IPP \(\frac{(IPP_{insp} + IPP_{exp})}{2}\) = 13.5 ± 3.3 cm H2O for an infused vol. of 2000 ml
61 patients
Linearly correlated with IP volume,
Higher if BMI higher
Higher incidence of enteric peritonitis with higher IPP

QUESTION:
Do you routinely measure IPP?

• 1: YES
• 2: NO
Three years down the road

- Patient eats less well, has not lost weight but displays edema and BP is high (165/92) despite three antihypertensive drugs: probable underdialysis
- Indeed, urine flow and RRF disappeared
- Only one episode of peritoneal infection just when called for transplantation (Gram negative last year)
- Peritoneal UF only 0.1 L despite shortening dwell length by adding a 4th exchange of 2.27% Physioneal (day dwells 4-5 hrs)
- $Kt/V_{\text{urea}}$ 1.62/week and Ccr 45 L/week/1.73 m$^2$

**QUESTION:**
What should we do now?

- 1: First do a new PET and measure IPP
- 2: Continue CAPD replacing one 1.36% by 3.86%
- 3: Transfer to APD
- 4: Transfer to HD

**ANSWER:** 1
PET category: High – IPP: 12 cm H₂O for 2 L
What could we propose?

• Stress salt and water restriction (no more RRF!)
• APD with 5 cycles of 2.5 L of 2.27% Physioneal 40 (or a mix of that with Nutrineal) and last fill of 2 L Extraneal : this requires new training

Assessment

• One week later, improved: - UF: 950 mL - Kt/Vₜₚₑₐ 1.85/w - Ccr 63 L/w/1.73m²
• Follow-up one month later: weight ↓ by 4 kg, BP normal with only two drugs, ↑ appetite, in general feels better.
Conclusion

• PD prescription is not difficult if we possess the information we need and if we understand the basics of transperitoneal solute and water passage
• We can even use shortened tests to explore those
• PD prescription has to be adapted to the patient’s evolution (lowering/loss of RRF, lifestyle)
• It is possible and probably sensible to minimise the use of glucose

QUESTION: Which approach? "One size fits all" or haute couture? (1) or (2)?
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<thead>
<tr>
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<th>Haute Couture or &quot;One size fits all&quot;?</th>
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<tbody>
<tr>
<td>Technique</td>
<td>Same technique (CAPD double bag)</td>
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<td>Number of exchanges</td>
<td>Same number and volume of exchanges</td>
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<td>Infusion volume</td>
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<td>Solution type</td>
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