PD: INFECTIOUS COMPLICATIONS

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Infectious complications in PD patients

- Some facts
- Exit site infection
- Tunnel infection
- Peritonitis

Overall first-year pneumonia event rates, by modality:
adjusted rates

![Graph showing overall first-year pneumonia event rates, by modality: adjusted rates.](USRDS ADR 2004)
Incident dialysis patients with 90-day rule; adjusted rates adjusted for age, gender, race, & primary diagnosis. Patients with Medicare as a secondary payer or enrolled in an HMO on day 90 are excluded, as are patients with septicemia claims overlapping the start date of the follow-up period.

Overall first-year hospital admission rates for septicemia, by modality: adjusted rates (Figure 6.38)

Hospitalization Rates due to infections by Euro-DOPPS Country

<table>
<thead>
<tr>
<th>Country</th>
<th>Vascular-related</th>
<th>Septicemia-related</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>0.02</td>
<td>0.04</td>
</tr>
<tr>
<td>Germany</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Italy</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Spain</td>
<td>0.03</td>
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</tr>
<tr>
<td>UK</td>
<td>0.08</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Reasons for transfer PD ⇒ HD

Rayner HC et al NDT 19:108-20, 2004

Rayner HC et al NDT 19:108-20, 2004
Exit site & Tunnel infection

Colonisation of exit site

Infection of exit site

Tunnel Infection

Peritoneal Infection

Loss of catheter + Technique failure

<table>
<thead>
<tr>
<th>TABLE 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Causes of Peritonitis</td>
</tr>
</tbody>
</table>

1. Contamination, most likely skin or environmental organisms
   - Contamination at the time of connection
   - Contamination from tubing
   - Hole in exchange tubing or catheter
   - Loss of catheter or exit of fluid or failure to close clamp
   - Product defects
2. Catheter related, most often staphylococcal species or Pseudomonas aeruginosa
   - Biofilm on internal portion of the catheter (relapsing, repeat peritonitis)
   - Exit site and tunnel infection
3. Bowel-source enteric organisms including gram-negative rods, Candida, and anaerobes
   - Peritonitis from E. coli, Klebsiella, Proteus, Citrobacter, and Enterobacter
   - Sepsis from anaerobic bacteria
   - C. difficile
4. Bacteremia, often Streptococcus or Staphylococcus
   - Transient from dental procedures
   - Infection of Intravenous device
5. Gynecologic source, often Streptococcus, Candida, some gram-negative rods
   - Peritonitis vaginal leak
   - Vaginal delivery
   - Hysteroscopy

Pirozzi B. et al. PDI 2011; 31:614-30
EXIT-SITE CARE TO PREVENT PERITONITIS

- Prevention of catheter infections (and thus peritonitis) is the primary goal of exit-site care. Antibiotic protocols against *S. aureus* are effective in reducing the risk of *S. aureus* catheter infections (66–81). (Evidence)
- All PD patients should use topical antibiotic either at the catheter exit site or intranasally or both (66, 70, 71, 73–75, 78, 82). (Evidence)
- Topical antibiotic ointments (as opposed to antibiotic creams) should not be used at the exit site of polyurethane catheters (82). (Evidence)

Piraino B. et al  PDI 2011; 31:614-30

PREVENTION OF BOWEL-SOURCE INFECTIONS

- Severe constipation and diarrhea can both be associated with peritonitis caused by enteric organisms (95, 96). (Evidence)
- Hypokalemia is associated with an increased risk of enteric peritonitis (97–99). (Evidence) Hypokalemia should therefore be avoided and, if present, treated. (Opinion)
- Invasive gastrointestinal procedures may infrequently cause peritonitis in PD patients (100–102). (Evidence) Intravenous antibiotic prophylaxis reduces early peritonitis in these patients (67). (Evidence)

Piraino B. et al  PDI 2011; 31:614-30

Methods for Reporting Peritoneal Dialysis-Related Infections (Peritonitis, Exit-Site Infections)

- 1. **As rates** (calculated for all infections and each organism):
  - Months of peritoneal dialysis at risk, divided by number of episodes, and expressed as interval in months between episodes
  - Number of infections by organism for a time period, divided by dialysis-years' time at risk, and expressed as episodes per year
- 2. **As percentage of patients** who are infection free per period of time
- 3. **As median infection rate** for the program (eg, calculate peritonitis rate for each patient and then obtain the median of these rates)
  - Relapsing peritonitis should be counted as a single episode (Opinion)
• Patient Education
  • Immediately report cloudy effluent, abdominal pain, and/or fever to PD unit
  • Save drained cloudy dialysate and bring to clinic
  • Treatment will be adding intraperitoneal antibiotics for up to 3 weeks
  • Report worsening symptoms or persistent cloudiness to PD unit
  • Schedule retraining for technique issues

• Outcomes evaluation
  Collect data to include:
  • Date of culture, organism identified, drug therapy used
  • Date infection resolved
  • Recurrent organisms, date of drug therapy
  • Method of interim renal replacement therapy
  • Date of catheter removal
  • Date of new catheter insertion
  • Documentation of contributing factors
  • Break in technique, patient factors, exit-site infections, tunnel infections
  • Date of reeducation/training
  • Enter data into catheter management database

REDUCING THE RISK OF RELAPSE AND REPEAT PERITONITIS

• Replacing the PD catheter in the setting of relapsing peritonitis will reduce the risk of subsequent relapse and repeat episodes (132, 133). (Evidence)

Peritonitis due to staphylococci

• Coagulase-negative staphylococcus peritonitis, including S. epidermidis, is due primarily to touch contamination, is generally a mild form of peritonitis, and responds readily to antibiotic therapy but can sometimes lead to relapsing peritonitis due to biofilm involvement. In such circumstances, catheter replacement is advised (Evidence).

• Staphylococcus aureus causes severe peritonitis. Although it may be due to touch contamination, it is often due to catheter infection. Staphylococcal peritonitis with concurrent exit-site or tunnel infection is unlikely to respond to antibiotic therapy without catheter removal (Evidence).

Rifampicin could be considered as an adjunct for the prevention of relapse or repeat S. aureus peritonitis but the enzyme-inducer effect of rifampicin should be considered in patients taking other medications (Opinion).
Other gram-positive

- In general, *streptococcal* peritonitis is readily curable by antibiotics but enterococcal peritonitis tends to be severe and is best treated with IP ampicillin when the organism is susceptible (Opinion).
- If *vancomycin-resistant enterococcus* (VRE) is ampicillin susceptible, ampicillin remains the drug of choice; otherwise, linezolid or quinupristin/dalfopristin should be used to treat VRE peritonitis (Opinion).
- *Corynebacterium* is an uncommon but significant cause of peritonitis and exit-site infection. Complete cure with antibiotics alone is possible in many patients (Opinion).
- Peritonitis due to multiple *gram-positive organisms* will generally respond to antibiotic therapy (Evidence).

Gram-negative organisms

- *Pseudomonas aeruginosa* peritonitis, similar to S. aureus peritonitis, is often related to a catheter infection and in such cases catheter removal will be required. Two antibiotics should always be used to treat P. aeruginosa peritonitis (Evidence).
- Single-organism gram-negative peritonitis may be due to touch contamination, exit-site infection, or transmural migration from constipation, diverticulitis, or colitis (Evidence).
- If multiple enteric organisms are grown, particularly in association with anaerobic bacteria, the risk of death is increased and a surgical evaluation should be obtained (Evidence).

Mycobacteria and fungi

- *Mycobacteria* are an infrequent cause of peritonitis and can be difficult to diagnose. When under clinical consideration, special attention must be paid to culture techniques. Treatment requires multiple drugs (Evidence).
- Fungal peritonitis is a serious complication and should be strongly suspected after recent antibiotic treatment for bacterial peritonitis. Catheter removal is indicated immediately after fungi are identified by microscopy or culture (Evidence).
PREVENTION OF FUNGAL PERITONITIS

- Most episodes of fungal peritonitis are preceded by courses of antibiotics (118–122). (Evidence)
- Fungal prophylaxis during antibiotic therapy may prevent some cases of Candida peritonitis in programs that have high rates of fungal peritonitis (118, 119, 123–130). (Evidence)

Pirano B. et al. PDI 2011; 31:614-30

In general,

- If a program has a rate of culture-negative peritonitis greater than 20%, then the culture methods should be reviewed and improved.

- Standard culture technique is the use of blood-culture bottles but a large-volume culture (e.g., culturing the sediment after centrifuging 50 mL of effluent) could further improve the recovery of micro-organisms (Evidence)

- The Committee feels that the minimum length of therapy for peritonitis is 2 weeks; although 3 weeks is recommended for more severe infections (Opinion). The Committee recommends removing the catheter for relapsing peritonitis, refractory peritonitis, fungal peritonitis, and refractory catheter infections. The focus should always be on preservation of the peritoneum rather than on saving the peritoneal catheter (Opinion)

Classification of normal and diseased exit sites in peritoneal dialysis patients (Twardowski ZJ and Prowant B, 1996)

<table>
<thead>
<tr>
<th>Classification</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exit color around catheter</td>
<td>natural, pale pink or dark</td>
<td>pink or bright pink or erythema &gt; 13 mm D/W</td>
<td>pink or bright pink or erythema &gt; 13 mm D/W</td>
<td>pink or bright pink or erythema &gt; 13 mm D/W</td>
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<tr>
<td>Cloud</td>
<td>none or small, easily detached</td>
<td>none or small, easily detached</td>
<td>present (may be large)</td>
<td>present (may be large)</td>
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<tr>
<td>Suck</td>
<td>absent</td>
<td>absent</td>
<td>absent</td>
<td>absent</td>
</tr>
<tr>
<td>External drainage</td>
<td>absent</td>
<td>absent</td>
<td>absent</td>
<td>absent</td>
</tr>
<tr>
<td>Erythema of the sinus</td>
<td>absent or barely visible</td>
<td>absent or barely visible</td>
<td>present (clear, purulent or bloody)</td>
<td>present (purulent or bloody)</td>
</tr>
<tr>
<td>Exudate in the sinus</td>
<td>absent or barely visible</td>
<td>absent or barely visible</td>
<td>present (clear, purulent or bloody)</td>
<td>present (purulent or bloody)</td>
</tr>
<tr>
<td>Granulation tissue</td>
<td>absent</td>
<td>absent</td>
<td>absent or slightly exuberant</td>
<td>absent or slightly exuberant</td>
</tr>
<tr>
<td>Epithelium (sinus)</td>
<td>strong, mature, whole sinus</td>
<td>partly covering sinus</td>
<td>partly covering sinus</td>
<td>partly covering sinus</td>
</tr>
<tr>
<td>Pain</td>
<td>absent</td>
<td>absent</td>
<td>absent</td>
<td>absent</td>
</tr>
<tr>
<td>Swelling</td>
<td>absent</td>
<td>absent</td>
<td>absent</td>
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</table>
Classification of exit sites

I
- perfect

II
- good

III
- equivocal

Twardowski ZJ and Prowant B, Perit Dial Int 1996

Catheter-associated infection

Acute exit site infection

Tunnel infection

Chronic exit site infection
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>
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</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>

Exit-site and tunnel infections

- Purulent drainage from the exit site indicates the presence of infection (do a swab + culture + US?). Erythema may or may not represent infection (Evidence)
- The most serious and common exit-site pathogens are Staphylococcus aureus and Pseudomonas aeruginosa. As these organisms frequently lead to peritonitis (Evidence), such infections must be treated aggressively
- Oral antibiotic therapy is generally recommended, with the exception of methicillin-resistant S. aureus (MRSA) (Opinion)

ISPD Guidelines 2010
Eosinophilic peritonitis: >10% dialysate eosinophils, most cases soon after catheter insertion

Chemical peritonitis: clinical symptoms similar to infectious peritonitis, but usually without fever, culture negative, causative agent

Hemoperitoneum: bloody dialysate, e.g. menstruation, ovulation,...

Chylous ascites: cloudy-white, normal dialysate cell count or slightly increased lymphocytes, increased triglycerides, negative cultures

Linked to medications: dihydropyridine CCB

Pancreatitis: negative cultures, dialysate amylase and lipase levels increased

Peritoneal carcinomatosis: negative cultures, positive cytology, occasionally symptoms of malignant disease

Specimen taken from a „dry“ abdomen: mostly on APD

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Eosinophilic Peritonitis (rare)

Observation
Cloudy effluent
no pain, no fever

Attitude
➢ Lab: cell count + formula!
➢ > 10% eosinophils
➢ no bacteria on Gram stain
➢ Negative Cultures
No treatment!!

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Clinical symptoms of peritonitis

- Cloudy dialysate 95-100%
- Abdominal pain (variable intensity) 70-95%
- Fever 20-80%
- Nausea, vomiting 20-80%
- Weight gain (ultrafiltration failure type 1) 25-75%
- 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

PD Fluid – how to sample

• Use first cloudy bag if possible – make sure patient brings it
• CAPD – from > 4 hr dwell
• APD – possibly a problem but think of children
  o If fluid turbid – use it, even the overnight fluid
  o If fluid clear – use dwell of > 2hours if patient has symptoms
  o If concerns – repeat samples
• Send to laboratory for urgent Gram stain, culture and white cell count
• Tell the microbiology laboratory if patient is on AB

PD fluid sample

• Send for gram stain and culture and differential white cell count (haematology)
• Looking for:
  o more than 100 white cells/mm3
  o more than 50% polymorphs
• Number of white cells/polymorphs at presentation is not predictive of organism or outcome
• **Initiate empirical therapy based on these results – immediately in a 6 hour dwell**
### PD Fluid sample (2)
- Take PD fluid sample into sterile containers and into a full blood count tube
- White cell count – how will it be done?
- Talk to haematology so they know what you are looking for and why

### PD Fluid sample (3)
**Gram stain**
- Strong indication but still preliminary
- Gram negative – think Pseudomonas
- Fungal – start treatment
- Gram +ve cocci and Gram –ve rods = polymicrobial perforation

### PD Fluid culture
- Must get it right to avoid culture negatives
- ISPD Guidelines give good guidance – discuss with your microbiology dept
- Key messages
  - Culture the first cloudy specimen
  - Use large volumes of fluid
  - Concentrate – filtration or centrifugation
  - Blood culture techniques
PD Fluid culture (2)

- 50 mls PD fluid at 3000g for 15 mins
- Resuspend in 3-5 mls sterile saline
- Inoculate into blood culture medium – aerobic and anaerobic
- Antibiotic neutralisation
- Rapid techniques
- Subculture the blood culture if required
- Talk to your microbiologist

Methods matter


- Compared standard vs blood culture +/- centrifugation – culture positive rate
  - Standard – 61%
  - Blood culture method – 84%
  - Blood culture with centrifugation – 93%
- Mean detection of growth – 19 hours

Reasons for Culture negative

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

**CAPD - peritonitis: portals of entry**

- **Intraluminal** (S. epidermidis, Acinetobacter)
- **Perituminal** (S. epidermidis, S. aureus, Pseudomonas, yeasts)
- **Transmural** (enteric gram-negative bacteria, Anaerobes)
- **Ascending** (yeasts, Lactobacillus)
- **Haematogenous** (Streptococcus, M. tuberculosis)

**Treatment of PD-peritonitis**

- Avoid peritoneal lavage
- Antibiotic therapy (IP, PO, IV)
- Intraperitoneal heparin
- Analgesic treatment
- Icodextrin and/or APD for ultrafiltration failure
Initial management of peritonitis

Start intraperitoneal antibiotics as soon as possible
Allow to dwell for at least 6 hours
Ensure gram-positive and gram-negative coverage
Base selection on historical patient and center sensitivity patterns as available

Ensure follow-up arrangements are clear or patient admitted
Await sensitivity results

Gram-positive coverage
Either first-generation cephalosporin or vancomycin
Either third-generation cephalosporin or aminoglycoside

ISPD Recommendations 2010  Perit Dial Int 2010

Initial empirical treatment of peritonitis
(Li et al, Perit Dial Int 30: 393-423, 2010)

INTRAPERITONEAL

aminoglycoside or ceftazidime or cefepime or carbapenem or aztreonam (if cephalo. allergy)

cefazolin or cephalothin or Vancomycin

Dependent on both patient’s and center’s history of causative organisms and sensitivities

Treatment of peritoneal dialysis-associated peritonitis: a review of randomized controlled trials (n=36)


• Intraperitoneal antibiotics (vancomycin/tobramycin) were more effective than intravenous therapy
• Continuous and intermittent dosing of vancomycin, gentamicin, ceftazidime and teicoplanin were equivalent
• Most antibiotic classes had similar efficacy rates (70-90% cure rate)
• Peritoneal lavage did not improve response rates
• Catheter removal/replacement was superior to urokinase in cases of relapsing peritonitis
• Once culture results and sensitivities are known, antibiotic therapy should be adjusted to narrow spectrum agents as appropriate.
  For patients with substantial residual renal function (residual GFR ≥ 5 mL/min/1.73 m²), the dose of antibiotics that have renal excretion may need to be adjusted accordingly (Opinion).

• Refractory peritonitis, defined as failure of the effluent to clear after 5 days of appropriate antibiotics, should be managed by removal of the catheter to protect the peritoneal membrane for future use (Evidence).

• Treatments of relapsing, recurrent, or repeat peritonitis represent distinct clinical entities that portend a worse outcome (particularly for recurrent peritonitis). Stronger consideration should be given to timely catheter removal (Opinion).

Subsequent management

Subsequent management of PD-peritonitis

If antibiotic therapy is appropriate: marked improvement should occur within 48 hours!

If no significant improvement within 48 hours:

• abdominal X-ray
• abdominal computed tomography
• sonography of the catheter tunnel (even in cases with perfect exit site)
• repeat dialysate cultures and consider adaptation of antibiotic therapy

Peritonitis

Duration of treatment

- *S. epidermidis and culture-negative*  2 weeks
- *Staphylococcus aureus*  3 weeks
- *Gram negative*  3 weeks
- *Enterococcus*  3 weeks
- *Candida species*  10 days after catheter removal
- *Aspergillus*  1-3 months
**Heparin during PD-peritonitis**

- Inhibition of intraperitoneal fibrin formation
- Decreased risk of catheter obstruction/adhesions
- Better availability of bacteria for antibiotics
- Dose: 500 - 1000 IU/Liter dialysate
- No transfer of heparin from the peritoneal cavity into blood (in contrast to low molecular weight heparin)
- Intrapерitoneal heparin probably necessary only in patients with low dialysate D-dimer levels
  (Nadig C et al, Perit Dial Int 1997)

**Analgesic treatment during peritonitis**

- Abdominal pain in 87% of peritonitis episodes
- Correlation between pain and hospitalization
- Coagulase-negative staphylococci: lower intensity of pain, no pain in 20% of cases
- All other cases: pain score > 6 in 80% of episodes
- Type and dosage of pain medication were inadequate in most of the cases
- Recommendation: do not hesitate to use opioids!
  (Piraino B et al, Perit Dial Int 1999)

**Peritoneal ultrafiltration with icodextrin versus conventional glucose solution in PD-peritonitis**

- *p < 0.0001

Posthuma N et al, 1997
### Peritonitis in APD patients

- In some studies lower peritonitis rate in APD patients as compared to CAPD patients, however with new systems no marked difference between treatment modalities
- Diagnosis may be delayed because of nighttime treatment and short dwells (patients may detect cloudy dialysate later, e.g. next morning)
- In some studies higher hospitalization rate for peritonitis in APD patients as compared to CAPD patients
- Elimination of antibiotics in APD: few data, clearances generally higher than with CAPD, elimination depends on dialysate flow during cycler therapy
- Outcome in APD patients with peritonitis in most studies comparable with CAPD patients

### Treatment of peritonitis in APD patients

#### Change to CAPD?

**Pros:**
- Possibly more appropriate antibiotic therapy (only few pharmacokinetic studies in APD patients), theoretically some antibiotics (e.g. cephalosporines) do not reach sufficient therapeutic dialysate levels during nighttime treatments when given 1x/24 h during daytime dwell, however: clinical studies show good cure rates!

**Cons:**
- For most APD patients it is logistically difficult to perform manual dialysate changes at home (no training, no material, need daytime flexibility for job,...)
- Sometimes ultrafiltration problems (during daytime exchanges) may occur even when icodextrin is used during nighttime
- Some patients may have inadequate small solute clearances when changing from APD to CAPD

### Terminology of peritonitis

- **Recurrent peritonitis:** an episode occurs within 4 weeks of completion of therapy of a prior episode (different organism)
- **Relapsing peritonitis:** an episode occurs within 4 weeks of completion of therapy of a prior episode (same organism)
- **Repeated peritonitis:** an episode occurs > 4 weeks after completion of therapy of a prior episode (same organism)
- **Refractory peritonitis:** failure of the effluent to clear after 5 days of antibiotic therapy (catheter removal!)
Differential causal diagnosis of relapsing, repeated or refractory peritonitis

- Inappropriate antibiotic therapy (consider also fungal and tuberculous peritonitis)
- Tunnel infection (sonography!)
- Abdominal abscesses (CT)
- Encapsulating Peritoneal Sclerosis
- Gynecologic disease
- Biofilm?

Fungal peritonitis

- Frequency: 1 – 5 (10)% of all episodes
- High mortality (17-44%) and morbidity (adhesions!)
- Most important causative organism: Candida (albicans, less frequently glabrata, tropicalis)
- Diagnosis: Gram - stain (up to 30% positive), dialysate culture
- Risk factors: immunosuppression, previous peritonitis or antibiotic therapy
  - Antimycotic therapy: combination of flucytosine (p.o.) and fluconazole (i.p.) or flucytosine (p.o.) and amphotericin B (i.v.) or voriconazole (i.v.), catheter removal as soon as possible!

Factors influencing mortality in peritoneal dialysis patients with fungal peritonitis

<table>
<thead>
<tr>
<th>Factor</th>
<th>Mortality if factor present</th>
<th>Mortality if factor not present</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diabetes mellitus</td>
<td>31 (5)</td>
<td>43 (22)</td>
<td>NS</td>
</tr>
<tr>
<td>Abdominal pain</td>
<td>52 (23)</td>
<td>14 (3)</td>
<td>0.002</td>
</tr>
<tr>
<td>Fever</td>
<td>58 (14)</td>
<td>29 (12)</td>
<td>NS</td>
</tr>
<tr>
<td>Antibiotic therapy within 3 months before peritonitis</td>
<td>48 (25)</td>
<td>13 (2)</td>
<td>NS</td>
</tr>
<tr>
<td>Ileus</td>
<td>79 (11)</td>
<td>31 (16)</td>
<td>0.002</td>
</tr>
<tr>
<td>Catheter remaining in situ</td>
<td>91 (10)</td>
<td>30 (17)</td>
<td>0.0005</td>
</tr>
<tr>
<td>Fungal peritonitis after Bacterial peritonitis</td>
<td>52 (17)</td>
<td>29 (10)</td>
<td>NS</td>
</tr>
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</table>
**Indications for catheter removal**

- Persistent exit site/tunnel infection despite adequate antibiotic therapy
- Refractory/relapsing peritonitis despite adequate antibiotic therapy
- Tunnel infection with simultaneous peritonitis
- Fecal peritonitis
- Fungal peritonitis, tuberculous peritonitis and Pseudomonas peritonitis (if no rapid improvement!)
- Intraabdominal/abdominal wall abscess
- Catheter dislocation or obstruction with malfunction

**PREVENTION**

**Risk of peritonitis with two different CAPD-systems**

![Graph showing risk of peritonitis with two different CAPD-systems](image-url)

- **Spike-system**:
  - Risk of peritonitis (%)
  - Time (months)
  - p<0.001

- **Y-system**:
  - Risk of peritonitis (%)
Efficacy of silver-ion implanted catheters in reducing peritoneal dialysis-related infections

Crabtree JII et al, Perit Dial Int 2003

Influence of PD training nurses’ experience on peritonitis rates (200 incident PD patients)


Prophylactic antibiotics for prevention of Staph. aureus induced catheter-related infection

<table>
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<tr>
<th>Author</th>
<th>Substance</th>
<th>Exit-site infection</th>
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<td>Zimmerman SW 1991</td>
<td>Rifampin p.o.</td>
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<td>Perez-Fontan M 1993</td>
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<tr>
<td>Bernardini J 1996</td>
<td>mupirocin (exit site) + rifampin p.o.</td>
<td>↓</td>
<td>↓</td>
</tr>
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<td>Thodis E 1998</td>
<td>Mupirocin (exit-site)</td>
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Antibiotic exit site cream for prevention of infectious complications in peritoneal dialysis patients


Systemic antibiotic prophylaxis

- Continuous antibiotic prophylaxis for all patients:
  - no evidence, risk of resistance and/or selection of other organisms, side effects
  → not recommended
- Antibiotic prophylaxis before dental surgery
  - no evidence, however hematogenous spreading theoretically possible
  → recommended
- Antibiotic prophylaxis before gastrointestinal endoscopy, abdominal or gynecological surgery:
  - no evidence, but some case reports of transmural/ascending peritonitis
  → recommended

Management of culture negative peritonitis

- With every peritonitis episode – determine follow up after initial treatment – admit or see each day?
- With every peritonitis episode – ensure that antibiotic dose is correct.
  - ISPD Guidelines – if > 100 ml urine, increase dose by 25%
  - Intermittent regimes – vancomycin on day 7 vs day 5 vs levels on day 4
- With every peritonitis episode – ensure antibiotic is stable and compatible in PD fluid/bag (de Vin PDI 2009; 29; 5-15)
- Culture negative defined at 72 hours – non-responding patient – what will you do?
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

1 patient / 2 escapes the risk of having peritonitis within 34-37 months

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
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!