What's new in peritoneal infection guidelines

Que hay de nuevo en las guias de infeccion peritoneal

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Infections associated with peritoneal dialysis

Update on Treatment Prevention
ISPD GUIDELINES/RECOMMENDATIONS

PERITONEAL DIALYSIS-RELATED INFECTIONS
RECOMMENDATIONS: 2010 UPDATE

Philip Kam-Tao Li,¹ Cheuk Chun Szeto,¹ Beth Piraino,² Judith Bernardini,² Ana E. Figueiredo,³ Amit Gupta,⁴ David W. Johnson,⁵ Ed J. Kuijper,⁶ Wai-Choong Lye,⁷ William Salzer,⁸ Franz Schaefer,⁹ and Dirk G. Struijk¹⁰

Members of the ISPD Ad Hoc Advisory Committee on Peritoneal Dialysis Related Infections

Philip Kam Tao Li    Hong Kong    (Chair)
Cheuk Chun Szeto    Hong Kong
Beth Piraino    USA
Judy Bernardini    USA, nurse
Ana E. Figueiredo    Brazil, nurse
David W Johnson    Australia
Amit Gupta    India
EJ Kuijper    Netherlands, microbiology
WC Lye    Singapore
William Salzer    USA, Infectious Disease
Franz Schaefer    Germany, pediatric
  nephrology
Dirk G. Struijk    Netherlands
International Society for Peritoneal Dialysis (ISPD)
Peritoneal Dialysis Related Infections - Recommendations

- 1983
- 1989
- 1993
- 1996
- 2000
- 2005
- 2010

- The previous recommendations included sections on treatment and prevention of peritonitis.

- In 2010 recommendations - focused on treatment of peritonitis

What does it cover?

Four sections
• Exit-site and tunnel infections
• Initial presentation and management of peritonitis
• Subsequent management (organism specific)
• Future research

NB. Prevention of PD-related infections will be covered in a separate ISPD position statement.
What’s new?

ISPD GUIDELINES/RECOMMENDATIONS

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RECOMMENDATIONS: 2010 UPDATE

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EJ Kuijper  Netherlands, microbiology
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Franz Schaefer  Germany, pediatric
nephrology
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1976 : Popovich & Moncrief
Two 1-L glass bottles
A long disposable transfer set
Peritonitis rate: 1 in 2.5 patient months

1978 : Oreopoulos
Plastic collapsible dialysate bag:
Peritonitis rate: 1 in 10.5 patient months
ISPD 2010 Guidelines

A Center’s peritonitis rate

No more than one episode every 18 months (0.67 per year at risk)

[the rate achieved will depend to some extent on the patient population]

Overall rates as low as 1 episode every 41 – 52 months (0.29 to 0.23/ year) have been reported, a goal which centers should strive to achieve

(Li 2002, Kim 2004)

12 PD Centers in HK

Overall CAPD peritonitis rates among different centres, Patient Months per Episode, 1.4.08 - 31.3.09

Patient Months

Hong Kong Renal Registry
Analysis of death of 296 PD patients

<table>
<thead>
<tr>
<th>Category</th>
<th>No. of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vascular diseases</td>
<td>142 (48.0%)</td>
</tr>
<tr>
<td>Sudden cardiac death</td>
<td>58 (19.6%)</td>
</tr>
<tr>
<td>Coronary artery disease</td>
<td>41 (13.9%)</td>
</tr>
<tr>
<td>Cerebrovascular disease</td>
<td>30 (10.1%)</td>
</tr>
<tr>
<td>Peripheral vascular disease</td>
<td>13 (4.4%)</td>
</tr>
<tr>
<td>Infections</td>
<td>82 (27.7%)</td>
</tr>
<tr>
<td>Non-peritonitis infection</td>
<td>33 (11.1%)</td>
</tr>
<tr>
<td>Peritonitis</td>
<td>49 (16.6%)</td>
</tr>
<tr>
<td>Others</td>
<td>72 (24.3%)</td>
</tr>
<tr>
<td>Liver cirrhosis</td>
<td>7 (2.4%)</td>
</tr>
<tr>
<td>Malignancy</td>
<td>13 (4.4%)</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>16 (5.4%)</td>
</tr>
<tr>
<td>Termination of dialysis</td>
<td>20 (6.8%)</td>
</tr>
<tr>
<td>Unknown</td>
<td>16 (5.4%)</td>
</tr>
<tr>
<td>Total</td>
<td>296</td>
</tr>
</tbody>
</table>
### Cause of Death in Peritoneal Dialysis Patients Dying Within 30 Days After Peritonitis Onset

Patients ($N=301$)

<table>
<thead>
<tr>
<th>Cause</th>
<th>($n$)</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peritonitis</td>
<td>80</td>
<td>26.6</td>
</tr>
<tr>
<td>Bacterial</td>
<td>61</td>
<td>20.3</td>
</tr>
<tr>
<td>Fungal</td>
<td>18</td>
<td>6.0</td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
<td>0.3</td>
</tr>
<tr>
<td>Encapsulating peritoneal sclerosis</td>
<td>2</td>
<td>0.7</td>
</tr>
</tbody>
</table>

Of the 3136 patients with peritonitis, 301 died within 30 days of the episode.

Peritonitis was named as the cause of death in 26.6% of those deaths,
• Exit-site and tunnel infections

• Initial presentation and management of peritonitis

• Subsequent management (organism specific)
Catheter replacement for ESI?

- retrospective review of refractory P. aeruginosa ESI (antibiotics for 7.6 ± 2.5 weeks)
- all received 7 days antibiotics after surgery
- CAPD resumed after 2 weeks of IPD
- no patient had ESI within 4 weeks after surgery
- 3 patients (8%) had recurrent ESI 24 to 40 weeks after surgery

**ISPD recommendation**: Simultaneous removal and reinsertion of the dialysis catheter is feasible in eradicating refractory exit-site infections due to Pseudomonas aeruginosa.

How about cuff shaving?

- retrospective review of 32 cuff-shaving procedures and 29 catheter replacement

- no significant difference in subsequent tunnel infection

- incidence of peritonitis due to post-surgery tunnel infection 6.8% vs 9.3%

- ISPD recommendation: In selected cases, cuff-shaving may be considered as the alternative to catheter replacement for tunnel infection.

• Exit-site and tunnel infections

• Initial presentation and management of peritonitis

• Subsequent management (organism specific)
Processing of PDE specimen

- Standard culture technique is the use of blood-culture bottles, but culturing the sediment after centrifuging 50 mL of effluent is ideal for low culture-negative results.

- Ideally, the specimens should arrive within 6 hours at the laboratory.

- Culture-negative peritonitis should not be greater than 20% of episodes.

CAPD Peritonitis: Broth Inoculation Culture versus Water Lysis Method

Rapid blood-culture techniques (BACTEC, Septi-Chek, BacT/Alert) speed up isolation and identification

Novel techniques for rapid diagnosis?

<table>
<thead>
<tr>
<th>Method</th>
<th>Publication</th>
</tr>
</thead>
</table>

Conclusion: There is not enough evidence for recommending the use of novel technique for the diagnosis of peritonitis.

Initial management

- 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

- 0-6 hours
  - Gram-positive coverage
    - Either first generation cephalosporin or vancomycin**
  - Gram-negative coverage
    - Either third-generation cephalosporin*** or aminoglycoside

- 6-8 hours
  - Determine and prescribe ongoing antibiotic treatment
  - Ensure follow-up arrangements are clear or patient admitted
  - Await sensitivity results

1st line in PWH: Cefazolin & Ceftazdime

Initial management: additional notes

- IP administration of antibiotics is superior to i.v. dosing for treating peritonitis.

- Intermittent and continuous dosing of antibiotics are equally efficacious.

- There is no role shown for routine peritoneal lavage.

- In addition to the above combinations, a variety of regimens have been tested in prospective trials with acceptable results:
  - ciprofloxacin + vancomycin / cefazolin
  - meropenam + tobramycin / vancomycin

Antibiotic level: the evidence

• review of 613 patients from a single centre

• dosing guideline for vancomycin produces adequate serum concentrations in > 85% of the patients

• in contrast, the currently recommended dosing of gentamicin resulted in high levels for >50% patients

• since IP antibiotics primarily act locally, checking antibiotic levels should be used for the detection of toxicity rather than a proof of efficacy

Urokinase for refractory peritonitis?

- RCT of 88 patients
- IP urokinase 60,000 IU vs placebo
- outcome
  - primary response rates 61.4 vs. 50%
  - relapse rates 9.1 vs. 13.6%
  - Tenckhoff catheter removal 22.7 vs. 29.5%
  - mortality 6.8 and 6.8%

Conclusion: IP urokinase plays no significant role as an adjuvant therapy in the treatment of bacterial CAPD peritonitis refractory to initial IP antibiotic therapy.

# Prediction of the peritonitis treatment failure

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Adjusted OR</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Causative organisms</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gram-positive only</td>
<td>Reference</td>
<td>—</td>
</tr>
<tr>
<td><strong>Gram-negative only</strong></td>
<td>2.86</td>
<td>0.014</td>
</tr>
<tr>
<td><strong>Pseudomonas or Xanthomonas</strong></td>
<td>34.7</td>
<td>0.001</td>
</tr>
<tr>
<td>polymicrobial</td>
<td>2.47</td>
<td>0.23</td>
</tr>
<tr>
<td><strong>mycobacterial</strong></td>
<td>5.08</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td><strong>fungal</strong></td>
<td>657</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>culture negative</td>
<td>1.98</td>
<td>0.28</td>
</tr>
<tr>
<td><strong>Diabetes</strong></td>
<td>3.34</td>
<td>0.018</td>
</tr>
<tr>
<td><strong>Peritoneal dialysate white count ≥1090/mm³ on day 3</strong></td>
<td>9.03</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

• review of 565 episodes of peritonitis
• further validation by another cohort of 217 episodes
• PDE white cell count $\geq 1090/\text{mm}^3$ on day 3 was an independent prognostic marker for treatment failure
  – sensitivity 75%
  – specificity 74%
  – hazard ratio 9.03

Comparative efficacy of dialysate white cell counts at various time points of the peritonitis to predict treatment failure

ROC curve of dialysate white counts (validation set)

- peritoneal dialysate white count 1090/mm3 on day 3
- sensitivity 75%
- specificity 74%

- review of 565 episodes of peritonitis
- further validation by another cohort of 217 episodes

Treatment failure:
- catheter loss or peritonitis-related death

### Peritonitis characteristics in the validation set according to the outcomes of treatment success versus failure

<table>
<thead>
<tr>
<th>Causative organisms</th>
<th>Treatment Success</th>
<th>Treatment Failure</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gram-positive only</td>
<td>91 (48%)</td>
<td>5 (31%)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Gram-negative only(^b)</td>
<td>49 (26%)</td>
<td>0 (0%)</td>
<td></td>
</tr>
<tr>
<td><em>Pseudomonas</em> or <em>Xanthomonas</em></td>
<td>13 (7%)</td>
<td>7 (43%)</td>
<td></td>
</tr>
<tr>
<td>Polymicrobial</td>
<td>13 (7%)</td>
<td>4 (25%)</td>
<td></td>
</tr>
<tr>
<td>Culture negative</td>
<td>25 (13%)</td>
<td>0 (0%)</td>
<td></td>
</tr>
<tr>
<td>Relapse peritonitis episode</td>
<td>16 (8%)</td>
<td>0 (0%)</td>
<td>0.62</td>
</tr>
<tr>
<td><strong>Peritoneal dialysate white count ≥ 1000/mm(^3) on day 3</strong></td>
<td>5 (3%)</td>
<td>9 (64%)</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

Treatment failure is defined as catheter loss or peritonitis-related death

In multiple logistic regression analyses,

Peritoneal dialysate white count >1090/mm³ on day 3
- an independent **prognostic marker for treatment failure** after adjustment for conventional risk factors

Hazard ratio 9.03

(95% confidence interval 4.40 to 18.6; \( P < 0.0001 \))

• Exit-site and tunnel infections

• Initial presentation and management of peritonitis

• Subsequent management (organism specific)
**Terminology for Peritonitis**

- **Recurrent**
  - An episode that occurs ≤ 4 weeks of completion of therapy of a prior episode but with a different organism
    - Frequently be successfully treated without catheter removal

- **Relapsing**
  - An episode that occurs ≤ 4 weeks of completion of therapy of a prior episode with the same organism or one sterile episode
    - Removing the catheter in most instances.

- **Repeat**
  - An episode that occurs > 4 weeks after completion of therapy of a prior episode with the same organism
    - Replacing the catheter prevents further episodes from that particular organism

- **Refractory**
  - Failure of the effluent to clear after 5 days of appropriate antibiotics
    - Clinicians should consider catheter removal

Relapsing vs recurrent: the relevance

• retrospective review
  – 157 relapsing episodes
  – 125 recurrent episodes
  – 764 control episodes

• more relapsing episodes were caused by
  – *Pseudomonas* species (16.6% versus 9.4%)
  – culture negative (29.9% versus 16.4%)

• recurrent infections commonly were caused by
  – *Enterococcus* species (3.2% versus 1.2%)
  – other GNB (27.2% versus 11.1%)
  – mixed growth (17.6% versus 12.7%)

Recurrent peritonitis episodes had a worse prognosis than relapsing ones.

- Lower primary response rate
- Lower complete cure rate
- Higher death rate

Choice of antibiotics
review of relapsing + recurrent episodes

Choice of G +ve coverage

**Vancomycin Vs Cefazolin**
- vancomycin as compared to cefazolin,
  - higher primary response rate
  - lower mortality

**Choice of G -ve coverage**

**Ceftazidime Vs Aminoglycoside**
- ceftazidime as compared to aminoglycoside
  - higher primary response rate
  - fewer catheter removal

Repeat
An episode that occurs > 4 weeks after completion of therapy of a prior episode with the same organism.

Relapsing
An episode that occurs ≤ 4 weeks of completion of therapy of a prior episode with the same organism or one sterile episode.

Conclusions Repeat peritonitis is a distinct clinical entity. Although repeat-peritonitis episodes generally have a satisfactory response to antibiotic, they have a substantial risk of developing further relapsing or repeat peritonitis.

Microbiological cause of the peritonitis episode

<table>
<thead>
<tr>
<th>Organisms</th>
<th>Repeat Group</th>
<th>Relapsing Group</th>
<th>Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gram-positive organisms</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>S. aureus</em></td>
<td>43 (23.8%)</td>
<td>5 (5.5%)</td>
<td>19 (15.2%)</td>
</tr>
<tr>
<td>CNSS</td>
<td>32 (17.7%)</td>
<td>16 (17.6%)</td>
<td>16 (12.8%)</td>
</tr>
<tr>
<td><em>Enterococcus</em> species</td>
<td>1 (0.6%)</td>
<td>0</td>
<td>5 (4.0%)</td>
</tr>
<tr>
<td>other <em>Streptococcus</em> sp.</td>
<td>15 (8.3%)</td>
<td>7 (7.7%)</td>
<td>21 (16.8%)</td>
</tr>
<tr>
<td>others</td>
<td>10 (5.5%)</td>
<td>7 (7.7%)</td>
<td>2 (1.6%)</td>
</tr>
<tr>
<td><strong>Gram negative organisms</strong></td>
<td>79 (43.6%)</td>
<td>56 (61.6%)</td>
<td></td>
</tr>
<tr>
<td><em>Pseudomonas</em> species</td>
<td>37 (20.4%)</td>
<td>22 (24.2%)</td>
<td>13 (10.4%)</td>
</tr>
<tr>
<td><em>E. coli</em></td>
<td>24 (13.3%)</td>
<td>11 (12.1%)</td>
<td>11 (8.8%)</td>
</tr>
<tr>
<td>others</td>
<td>18 (9.9%)</td>
<td>23 (25.3%)</td>
<td>29 (23.2%)</td>
</tr>
<tr>
<td><strong>Fungi</strong></td>
<td>1 (0.6%)</td>
<td>0</td>
<td>6 (4.8%)</td>
</tr>
<tr>
<td><strong>Mycobacterium</strong></td>
<td>0</td>
<td>0</td>
<td>5 (2.4%)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>181</td>
<td>91</td>
<td>125</td>
</tr>
</tbody>
</table>
Repeat peritonitis in peritoneal dialysis: retrospective review of 181 consecutive cases.

- In Repeat Group, 24% were due to Staphylococcus aureus, as compared with 5.5% in Relapsing Group.

- Majority of the organisms causing relapsing peritonitis were Gram negative (62%).

- Majority of that in Repeat Group were Gram positive (56%).

- Repeat Group had a lower complete-cure rate (70.7% versus 54.9%) than Relapsing Group.

**Epidemiology and outcomes of peritoneal dialysis-related peritonitis infection secondary to different organisms**

<table>
<thead>
<tr>
<th>Micro-organisms</th>
<th>Percentage of all peritonitis</th>
<th>Incidence (episodes per patient-year)</th>
<th>Complete cure rate*</th>
<th>Relapse rate†</th>
<th>Tenckhoff catheter loss</th>
<th>Death</th>
</tr>
</thead>
</table>
| Coagulase-negative staphylococci
type 52,53                 | 11.4 - 26.0%                  | 0.064 - 0.16                          | 71.1 - 76.5%        | 14.2 - 16.9%    | 2.2 - 9.7%              | 0.4 - 1.0% |
| *Staphylococcus aureus* type 54,55 | 11.9 - 14.0%                  | 0.072 - 0.08                          | 74.3%               | 8.6 - 20.0%    | 5.7 - 31.5%             | 2.0 – 2.2% |
| *Pseudomonas* species 63,64,65 | 3.4 - 13.2%                  | 0.032 - 0.20                          | 22.1 - 32.3%        | 9.0 - 14.4%    | 39.4 - 44.0%‡          | 3.1 - 6.5% |
| Enterobacteriaceae species 66 § | 12.0%                        | 0.198                                 | 58.1%               | 14.3%         | 8.1%                    | 5.2%   |
| Fungus 70,71              | 4.5 – 5.5%                    | 0.03                                  | Not reported        | Not reported   | 82.9 - 87.7%            | 8.6 – 40.6% |

* Complete cure is defined as complete resolution of peritonitis by antibiotics alone without relapse or recurrence within 4 weeks of completion of therapy.
† A relapse is defined as a recurrence of peritonitis due to the same organism occurring within the last antibiotic dose.
‡ Before the widely adopted treatment strategy of administering two antipseudomonal antibiotics for *Pseudomonas* peritonitis, the catheter loss rate was 61.3%.
§ The most common Enterobacteriaceae species was *Escherichia coli.*

Li PKT, Chow KM. Nature Reviews Nephrology (Epub 2011 Dec 20)
Epidemiology of peritoneal dialysis-related peritonitis infection secondary to different organisms

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<td>0.03</td>
</tr>
</tbody>
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The most common Enterobacteriaceae species was *Escherichia coli*.

Li PKT, Chow KM. Nature Reviews Nephrology 2012 (Feb); 8: 77-88
# Distribution of Peritonitis by Cause ANZDATA 2003-06

<table>
<thead>
<tr>
<th>Cause</th>
<th>Percentage</th>
<th>Organism</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coagulase negative Staph (CNS) / Staph epi</td>
<td>26%</td>
<td>Pseudomonas</td>
<td>5%</td>
</tr>
<tr>
<td>non-Pseudomonas Gram-negative (NPGN)</td>
<td>17%</td>
<td>Streptococcus</td>
<td>5%</td>
</tr>
<tr>
<td>Staph aureus</td>
<td>14%</td>
<td>Fungus</td>
<td>5%</td>
</tr>
<tr>
<td>Culture negative</td>
<td>12%</td>
<td>Enterococcus</td>
<td>2%</td>
</tr>
<tr>
<td>Polymicrobial</td>
<td>10%</td>
<td>Diphtheroids</td>
<td>2%</td>
</tr>
</tbody>
</table>
Staphylococcus aureus

- retrospective review of 245 episodes (45 episodes of MRSA)
- history of recent hospitalization had a higher risk for isolation of MRSA (30.6% vs 14.2%)

- outcome
  - primary response rate 87.8%
  - complete cure rate was 74.3%
  - relapse episode 8.6%
  - repeat episode 24.1%

Staphylococcus aureus Peritonitis - Treatment

- Vancomycin vs cefazolin as initial treatment
  - better primary response rate (98.0% vs 85.2%, p = 0.001)
  - similar complete cure rate

- **Adjuvant rifampicin** treatment was associated with a significantly lower risk for relapse or repeat peritonitis (21.4% vs 42.8%, p = 0.004)

**ISPD recommendation**: Rifampicin could be considered as an adjunct for the prevention of relapse or repeat peritonitis, but the enzyme inducer effect should be considered in patients taking other medications.

Coagulase negative staphylococcus

• retrospective review of 232 episodes
• outcome
  – primary response rate 95.3%
  – complete cure rate 71.1%
  – relapse peritonitis 14.2%
  – repeat peritonitis 12.5%
• recent hospitalization or recent antibiotic therapy had a higher risk of having methicillin-resistant strains
• initial treatment with cefazolin or vancomycin had similar primary response rate and complete cure rate

Absolute peritonitis rate of coagulase-negative Staphylococcus species (CNSS) peritonitis during the 12-yr study period

from 1995 to 1999: total rate irrespective of sensitivity to methicillin

, methicillin-sensitive strains

, methicillin-resistant strains

Coagulase negative staphylococcus
Treatment of relapse / repeat episodes?

- for relapse or repeat episodes, treatment with effective antibiotics for 3 weeks was associated with a significantly higher complete cure rate than 2-week treatment (83.3% vs 46.7%, p = 0.047)

**ISPD recommendation**: Coagulase-negative staphylococcus peritonitis … sometimes lead to relapsing peritonitis due to biofilm involvement. In such circumstances catheter replacement is advised.

Streptococcus

- retrospective review of 287 episodes

- Compared with other organisms, streptococcal peritonitis was associated with significantly lower risks of
  - relapse (3% vs 15%)
  - catheter removal (10% vs 23%)
  - permanent HD (9% vs 18%)
  - shorter hospitalisation (5 vs 6 days)

Conclusion: readily treatable with either first-generation cephalosporins or vancomycin for 2 weeks

In general, streptococcal peritonitis are readily curable by antibiotics, but enterococcal peritonitis tend to be severe and are best treated with IP ampicillin when the organism is susceptible.

If VRE are ampicillin susceptible, ampicillin remains the drug of choice.

Otherwise, linezolid or quinupristin/dalfopristin should be used.
Enterococcal peritonitis in Australian peritoneal dialysis patients: predictors, treatment and outcomes in 116 cases

• Polymicrobial peritonitis significantly more common when an *Enterococcus* species was isolated

• only 8% of patients with pure enterococcal peritonitis were treated with intraperitoneal ampicillin therapy

• the majority (78%) received vancomycin monotherapy.

Overall, 59 (51%) patients with enterococcal peritonitis were successfully treated with antibiotics without experiencing relapse, catheter removal or death.

The sole independent predictor of adverse clinical outcomes was recovery of additional (non-Enterococcus) organisms.

Clinical outcomes were broadly comparable for pure enterococcal and non-enterococcal peritonitis.
SPICE Organisms

- Serratia,
- Pseudomonas,
- Indol-positive organisms such as Providencia,
- Citrobacter,
- Enterobacter

- seem to have a particularly high risk of relapse.

## Prediction of the peritonitis treatment failure

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Adjusted OR</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Causative organisms</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gram-positive only</td>
<td>Reference</td>
<td>—</td>
</tr>
<tr>
<td>Gram-negative only</td>
<td>2.86</td>
<td>0.014</td>
</tr>
<tr>
<td>Pseudomonas or Xanthomonas</td>
<td>34.7</td>
<td>0.001</td>
</tr>
<tr>
<td>polymicrobial</td>
<td>2.47</td>
<td>0.23</td>
</tr>
<tr>
<td><strong>mycobacterial</strong></td>
<td>5.08</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td><strong>fungal</strong></td>
<td>657</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>culture negative</td>
<td>1.98</td>
<td>0.28</td>
</tr>
<tr>
<td><strong>Diabetes</strong></td>
<td>3.34</td>
<td>0.018</td>
</tr>
<tr>
<td>Peritoneal dialysate white count ≥1090/mm³ on day 3</td>
<td>9.03</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

Gram negative organisms: incidence by year

In Nissenson AR and Fine R : Dialysis Therapy (4th Ed) 2007: Chapter 32; pp396-413
Pseudomonas: what’s new?

- retrospective review of 191 episodes
- initial antibiotic choice did not influence outcomes
- subsequent use of dual anti-pseudomonal therapy was associated with a lower risk for permanent HD (10% vs 38%, p = 0.03)
- catheter removal was associated with a lower risk for death than antibiotics alone (0% vs 6%, p < 0.05)

Gram negative organisms: incidence by year

In Nissenson AR and Fine R : Dialysis Therapy (4th Ed) 2007: Chapter 32; pp396-413
<table>
<thead>
<tr>
<th>Enterobacterial species</th>
<th>No. of cases (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Escherichia coli</em></td>
<td>111 (52.9%)</td>
</tr>
<tr>
<td><em>Klebsiella Species</em></td>
<td>57 (27.1%)</td>
</tr>
<tr>
<td><em>Enterobacter species</em></td>
<td>12 (5.7%)</td>
</tr>
<tr>
<td><em>Serratia species</em></td>
<td>18 (8.6%)</td>
</tr>
<tr>
<td><em>Citrobacter species</em></td>
<td>10 (4.8%)</td>
</tr>
<tr>
<td><em>Morganella species</em></td>
<td>1 (0.5%)</td>
</tr>
<tr>
<td><em>Proteus species</em></td>
<td>1 (0.5%)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>210</strong></td>
</tr>
</tbody>
</table>

Szeto CC, ..., Li PKT. Kidney Int 2006; 69: 1245–1252
Peritonitis caused by Enterobacteriaceae

- may be due to
  - Touch contamination
  - Exit site infection
  - Bowel source, such as
    - constipation,
    - colitis or
    - transmural migration,
  - Etiology unclear.

Incidence of Enterobacteriaceae peritonitis over 10 years

Szeto CC, .., Li PKT. Kidney Int 2006; 69: 1245-1252.
Primary response rate - 84.8%

Complete cure rate - 58.1%.

Exit site infection was associated with a lower complete cure rate (43.2 versus 61.3%, \( P=0.034 \))

Patients treated with **two antibiotics** had a marginally lower risk of relapse and recurrence than those with one antibiotic (21.4 versus 36.1%, \( P=0.051 \))

Recent antibiotic therapy is the major risk factor of antibiotic resistance.

Treatment with two antibiotics may reduce the risk of relapse and recurrence.

Szeto CC,…, Li PKT. Kidney Int 2006; 69: 1245–1252
Mixed growth: when to worry

• systemic review of published literature

• suspect surgical problem if
  – hypotension
  – systemic sepsis
  – lactic acidosis
  – elevation of peritoneal dialysate effluent (PDE) amylase
  – rapid gram staining of PDE revealing mixed bacterial population

TB Peritonitis

• Treatment with standard antituberculosis drugs for an extended period of 12 months appears to be effective.

• **Removal** of the peritoneal dialysis catheter is **not mandatory**

• **long-term continuation** of CAPD after tuberculous peritonitis is **possible**.

Mixed Growth
Gram positive
Gram negative
Culture negative
Mixed Growth
Fungus
Tuberculosis

In Nissenson AR and Fine R : Dialysis Therapy (4th Ed) 2007: Chapter 32; pp396-413
Fungal peritonitis

- retrospective review of 162 episodes

- Candida albicans and other Candida species were most common (25% and 44%, respectively)

- risks of relapse and death were lowest with catheter removal combined with antifungal therapy when compared to either intervention alone

- Compared with other micro-organisms, fungal peritonitis was associated with higher rates of hospitalization, catheter removal, transfer to hemodialysis, and death

Fungal peritonitis
ISPD recommendations

• Catheter removal is indicated immediately after fungi are identified by microscopy or culture.
• treatment
  – initial therapy may be a combination of amphotericin B and flucytosine until the sensitivity results are available
  – Fluconazole orally with flucytosine is another option

  – voriconazole or posaconazole are alternatives for amphotericin B when filamentous fungi (but not Candida)

  – echinocandins (e.g. caspofungin, micafungin, and anidulafungin) has been advocated for the treatment of fungal peritonitis attributable to Aspergillus and non-responding non-albicans Candida, or in patients intolerant to other antifungal therapies

  – Therapy should be for an additional 10 days after catheter removal.

Overall cumulative probability of antibiotic-related fungal peritonitis-free survival in nystatin-treated group

Wong PN et al. Perit Dial Int 2007; 27:531–536
Statistically significant difference was found between the use of prophylactic fluconazole in patients with bacterial peritonitis (0.92%) and non-use of prophylactic fluconazole (6.45%), demonstrating the drug's ability to prevent emergence of secondary fungal peritonitis ($p = 0.0051$).
Prophylaxis for Fungal peritonitis
ISPD recommendations

• Fungal prophylaxis during antibiotic therapy may prevent some cases of Candida peritonitis in programs that have high rates of fungal peritonitis

• Each PD program must examine its history of fungal peritonitis and decide whether such a protocol might be beneficial.

Values of Antibiotics

- A 3-wk course of antibiotic can probably achieve a higher cure rate in relapse or repeat episodes in Coagulase Negative Staphylococcal Peritonitis
  

- Rifampicin is a valuable adjunct in preventing relapse and repeat *S. aureus* peritonitis after the index episode.
  

- Treatment with two antibiotics may reduce the risk of relapse and recurrence of Enterobacteriaceae peritonitis
  
  Szeto CC,…, Li PKT. Kidney Int 2006; 69: 1245–1252
Duration of treatment

- In patients who respond slowly to the initial antibiotic therapy (especially episodes caused by
  - S. aureus,
  - gram-negative, or
  - enterococcal peritonitis),

a 3-week treatment is recommended
(whether the catheter is removed or not)

Indications for Catheter Removal for Peritoneal Dialysis-Related Infections

- Refractory peritonitis
- Relapsing peritonitis
- Refractory exit-site and tunnel infection
- Fungal peritonitis
- Catheter removal may also be considered for
  - Repeat peritonitis
  - Mycobacterial peritonitis
  - Multiple enteric organisms

Ways of removing catheter

1. Simultaneous catheter replacement
   [For
   – refractory exit-site infections
   – relapsing peritonitis, if the effluent can first be cleared and procedure should be done under antibiotic coverage]

2. Time period between catheter removal for infection and reinsertion of a new catheter
   [For refractory peritonitis and fungal peritonitis]
   – Optimum time not known
   – Empirically, a minimum period of 2 – 3 weeks (4 weeks in PWH) between catheter removal and reinsertion of a new catheter is recommended
   – (Opinion)

Infections associated with peritoneal dialysis

Update on Treatment Prevention
Strategies to prevent Peritonitis

- Selection of PD catheter design and insertion technique
- Use of antibiotics at the time of PD catheter insertion
- Patient training
- PD connectology
- Exit site care
- Peri-procedural prophylaxis
- Choice of PD solutions
Currently available peritoneal catheters in combinations of intraperitoneal and extraperitoneal designs

Li PKT, Chow KM, Ash SR. History of Peritoneal Dialysis Catheters. in Ing TS, Rahman MA, Kjellstrand CM eds In Search of Optimal Dialysis: Building on Knowledge to Secure A Better Future (in Press)
No particular catheter has been definitively shown to be better than the standard silicon Tenckhoff catheter for prevention of peritonitis. (evidence)

(evidence)


Prophylactic antibiotics administered at the time of insertion decrease infection risk. (evidence)

(IP Vancomycin or 1st generation cephalosporin like cephalozolin)


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 (evidence)

Strategies to prevent Peritonitis

• Selection of PD catheter design and insertion technique
• Use of antibiotics at the time of PD catheter insertion
• Patient training
• PD connectology
• Exit site care
• Peri-procedural prophylaxis
• Choice of PD solutions
Intraluminal
(Touch contamination)

Improvement of connection technology

Bacterial access in CAPD Peritonitis

Periluminal (catheter tract)

Transvisceral
*Incidence of CAPD peritonitis*

- **Standard:** 11.4 patient-month/episode
- **Y-set:** 20.7
- **Double-bag:** 25 – 46.4 **Comparable**
- **Our study**
  - Ultrabag 45
  - Stay-safe 36.8

Li PKT et al. Am J Kidney Dis 2002
Daly CD et al. Nephrol Dial Transplant 2000
Li PKT et al. Am J Kidney Dis 1999
### Y Set Vs Standard Spike

<table>
<thead>
<tr>
<th>Study or sub-category</th>
<th>Treatment n/N</th>
<th>Control n/N</th>
<th>RR (random) 95% CI</th>
<th>Weight %</th>
<th>RR (random) 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Li 1996</td>
<td>7/20</td>
<td>11/20</td>
<td></td>
<td>6.36</td>
<td>0.64 [0.31, 1.30]</td>
</tr>
<tr>
<td>Rottenburg 1987</td>
<td>9/27</td>
<td>14/28</td>
<td></td>
<td>7.69</td>
<td>0.67 [0.35, 1.28]</td>
</tr>
<tr>
<td>Maiorca 1983</td>
<td>10/32</td>
<td>17/30</td>
<td></td>
<td>8.91</td>
<td>0.55 [0.30, 1.01]</td>
</tr>
<tr>
<td>Churchill 1989</td>
<td>15/61</td>
<td>30/63</td>
<td></td>
<td>12.18</td>
<td>0.52 [0.31, 0.86]</td>
</tr>
<tr>
<td>Lindholm 1988</td>
<td>16/35</td>
<td>18/23</td>
<td></td>
<td>17.43</td>
<td>0.58 [0.38, 0.89]</td>
</tr>
<tr>
<td>Owen 1991</td>
<td>14/30</td>
<td>27/30</td>
<td></td>
<td>19.02</td>
<td>0.52 [0.35, 0.77]</td>
</tr>
<tr>
<td>Monteon 1998</td>
<td>35/57</td>
<td>20/29</td>
<td></td>
<td>28.41</td>
<td>0.89 [0.65, 1.23]</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>262</td>
<td>223</td>
<td></td>
<td>100.00</td>
<td>0.64 [0.33, 0.77]</td>
</tr>
</tbody>
</table>

Total events: 106 (Treatment), 137 (Control)
Test for heterogeneity: Chi² = 6.45, df = 6 (P = 0.38), I² = 6.9%
Test for overall effect: Z = 4.75 (P < 0.00001)

#### Peritonitis

<table>
<thead>
<tr>
<th>Study</th>
<th>Treatment n/N</th>
<th>Control n/N</th>
<th>RR (random) 95% CI</th>
<th>Weight %</th>
<th>RR (random) 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maiorca 1983</td>
<td>11/363</td>
<td>31/361</td>
<td></td>
<td>8.16</td>
<td>0.34 [0.16, 0.67]</td>
</tr>
<tr>
<td>Li 1996</td>
<td>14/238</td>
<td>19/237</td>
<td></td>
<td>8.29</td>
<td>0.67 [0.35, 1.31]</td>
</tr>
<tr>
<td>Rottenburg 1987</td>
<td>12/277</td>
<td>28/344</td>
<td></td>
<td>8.46</td>
<td>0.53 [0.28, 1.03]</td>
</tr>
<tr>
<td>Lindholm 1988</td>
<td>13/284</td>
<td>28/225</td>
<td></td>
<td>8.97</td>
<td>0.37 [0.20, 0.69]</td>
</tr>
<tr>
<td>Churchill 1989</td>
<td>21/452</td>
<td>47/467</td>
<td></td>
<td>13.00</td>
<td>0.46 [0.26, 0.76]</td>
</tr>
<tr>
<td>Cheng 1994</td>
<td>26/802</td>
<td>64/1583</td>
<td></td>
<td>15.06</td>
<td>0.80 [0.51, 1.25]</td>
</tr>
<tr>
<td>Owen 1991</td>
<td>28/375</td>
<td>88/431</td>
<td></td>
<td>17.35</td>
<td>0.37 [0.24, 0.55]</td>
</tr>
<tr>
<td>Monteon 1998</td>
<td>57/671</td>
<td>55/337</td>
<td></td>
<td>20.70</td>
<td>0.52 [0.37, 0.74]</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>3462</td>
<td>1955</td>
<td></td>
<td>100.00</td>
<td>0.49 [0.40, 0.61]</td>
</tr>
</tbody>
</table>

Total events: 182 (Treatment), 360 (Control)
Test for heterogeneity: Chi² = 9.64, df = 7 (P = 0.21), I² = 27.4%
Test for overall effect: Z = 6.56 (P < 0.00001)

#### Peritonitis rate

<table>
<thead>
<tr>
<th>Study</th>
<th>Treatment n/N</th>
<th>Control n/N</th>
<th>RR (random) 95% CI</th>
<th>Weight %</th>
<th>RR (random) 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maiorca 1993</td>
<td>0/32</td>
<td>2/30</td>
<td></td>
<td>1.41</td>
<td>0.19 [0.01, 3.96]</td>
</tr>
<tr>
<td>Owen 1991</td>
<td>14/30</td>
<td>13/30</td>
<td></td>
<td>40.18</td>
<td>1.08 [0.62, 1.89]</td>
</tr>
<tr>
<td>Churchill 1989</td>
<td>22/61</td>
<td>23/63</td>
<td></td>
<td>58.21</td>
<td>0.99 [0.62, 1.58]</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>123</td>
<td>123</td>
<td></td>
<td>100.00</td>
<td>1.00 [0.70, 1.43]</td>
</tr>
</tbody>
</table>

Total events: 36 (Treatment), 38 (Control)
Test for heterogeneity: Chi² = 1.30, df = 2 (P = 0.52), I² = 0%
Test for overall effect: Z = 0.00 (P = 1.00)

#### Exit-site/tunnel infection

<table>
<thead>
<tr>
<th>Study</th>
<th>Treatment n/N</th>
<th>Control n/N</th>
<th>RR (random) 95% CI</th>
<th>Weight %</th>
<th>RR (random) 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Li 1996</td>
<td>9/228</td>
<td>10/217</td>
<td></td>
<td>12.53</td>
<td>0.82 [0.34, 1.96]</td>
</tr>
<tr>
<td>Cheng 1994</td>
<td>54/803</td>
<td>81/1583</td>
<td></td>
<td>87.47</td>
<td>1.31 [0.94, 1.63]</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1041</td>
<td>1800</td>
<td></td>
<td>100.00</td>
<td>1.24 [0.91, 1.69]</td>
</tr>
</tbody>
</table>

Total events: 63 (Treatment), 91 (Control)
Test for heterogeneity: Chi² = 0.96, df = 1 (P = 0.33), I² = 0%
Test for overall effect: Z = 1.36 (P = 0.18)
### Study Results

<table>
<thead>
<tr>
<th>Study or sub-category</th>
<th>Treatment</th>
<th>Control</th>
<th>RR (random)</th>
<th>Weight %</th>
<th>RR (random)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n/N</td>
<td>n/N</td>
<td>95% CI</td>
<td></td>
<td>95% CI</td>
</tr>
<tr>
<td>Harris 1996</td>
<td>5/33</td>
<td>12/30</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>21.12</td>
<td>0.38</td>
<td>[0.15, 0.95]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Li 1999</td>
<td>21/60</td>
<td>19/51</td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>37.99</td>
<td>0.94</td>
<td>[0.57, 1.54]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monteon 1998</td>
<td>18/61</td>
<td>35/57</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>40.89</td>
<td>0.48</td>
<td>[0.31, 0.75]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total (95% CI)</td>
<td>154</td>
<td>138</td>
<td></td>
<td>100.00</td>
<td>0.59</td>
</tr>
</tbody>
</table>

Test for heterogeneity: Chi² = 5.69, df = 2 (P = 0.08), I² = 60.7%
Test for overall effect: Z = 1.94 (P = 0.05)

#### Peritonitis

<table>
<thead>
<tr>
<th>Study or sub-category</th>
<th>Treatment</th>
<th>Control</th>
<th>RR (random)</th>
<th>Weight %</th>
<th>RR (random)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n/N</td>
<td>n/N</td>
<td>95% CI</td>
<td></td>
<td>95% CI</td>
</tr>
<tr>
<td>Kiernan 1994</td>
<td>15/176</td>
<td>5/170</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>18.41</td>
<td>2.90</td>
<td>[1.08, 7.80]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Harris 1996</td>
<td>7/326</td>
<td>23/322</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>21.43</td>
<td>0.30</td>
<td>[0.13, 0.69]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Li 1999</td>
<td>28/937</td>
<td>25/734</td>
<td></td>
<td></td>
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<td></td>
<td>27.97</td>
<td>0.88</td>
<td>[0.52, 1.49]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monteon 1998</td>
<td>81/983</td>
<td>57/671</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>32.19</td>
<td>0.97</td>
<td>[0.70, 1.34]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total (95% CI)</td>
<td>2422</td>
<td>1897</td>
<td></td>
<td>100.00</td>
<td>0.90</td>
</tr>
</tbody>
</table>

Test for heterogeneity: Chi² = 12.24, df = 3 (P = 0.007), I² = 75.5%
Test for overall effect: Z = 0.35 (P = 0.73)

#### Peritonitis rate

<table>
<thead>
<tr>
<th>Study or sub-category</th>
<th>Treatment</th>
<th>Control</th>
<th>RR (random)</th>
<th>Weight %</th>
<th>RR (random)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n/N</td>
<td>n/N</td>
<td>95% CI</td>
<td></td>
<td>95% CI</td>
</tr>
<tr>
<td>Harris 1996</td>
<td>4/326</td>
<td>8/322</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>21.30</td>
<td>0.49</td>
<td>[0.15, 1.62]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kiernan 1994</td>
<td>14/176</td>
<td>6/170</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>28.33</td>
<td>2.25</td>
<td>[0.89, 5.73]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Li 1999</td>
<td>54/937</td>
<td>46/734</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50.37</td>
<td>0.92</td>
<td>[0.63, 1.35]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total (95% CI)</td>
<td>1439</td>
<td>1226</td>
<td></td>
<td>100.00</td>
<td>1.04</td>
</tr>
</tbody>
</table>

Test for heterogeneity: Chi² = 4.44, df = 2 (P = 0.11), I² = 55.0%
Test for overall effect: Z = 0.11 (P = 0.91)

### Exit-site/tunnel infection rate

---

APD vs CAPD

• Data on peritonitis rates in automated PD (APD) and continuous ambulatory PD (CAPD) are conflicting (Evidence)

• The decision on modality (APD vs CAPD) should not be based on peritonitis risk (Opinion)

Strategies to prevent Peritonitis

- Selection of PD catheter design and insertion technique
- Use of antibiotics at the time of PD catheter insertion
- Patient training
- PD connectology
- Exit site care
- Peri-procedural prophylaxis
- Choice of PD solutions
## Commercially available, neutral pH, low-GDP PD solutions

<table>
<thead>
<tr>
<th>Buffer (mmol/l)</th>
<th>Chambers</th>
<th>Lactate</th>
<th>Bicarbonate</th>
<th>Final pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balance</td>
<td>2</td>
<td>35</td>
<td>—</td>
<td>6.8</td>
</tr>
<tr>
<td>Bicavera</td>
<td>2</td>
<td>—</td>
<td>34/39</td>
<td>7.1</td>
</tr>
<tr>
<td>Gambrosol Trio</td>
<td>3</td>
<td>39–41</td>
<td>—</td>
<td>6.5</td>
</tr>
<tr>
<td>Physioneal</td>
<td>2</td>
<td>10/15</td>
<td>25</td>
<td>7.3</td>
</tr>
<tr>
<td>Conventional</td>
<td>1</td>
<td>35/40</td>
<td>—</td>
<td>5.0–5.4</td>
</tr>
</tbody>
</table>

Clinical outcomes using low-GDP neutral pH PD solutions

<table>
<thead>
<tr>
<th>Study</th>
<th>N</th>
<th>Follow-up</th>
<th>Solution</th>
<th>Peritonitis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Williams et al.</td>
<td>86</td>
<td>24 Weeks (12/12)</td>
<td>Balance</td>
<td>↔</td>
</tr>
<tr>
<td>Fan et al.</td>
<td>93</td>
<td>1 Year</td>
<td>Physioneal/balance</td>
<td>↔</td>
</tr>
<tr>
<td>Choi et al.</td>
<td>104</td>
<td>1 Year</td>
<td>Balance</td>
<td>NR</td>
</tr>
<tr>
<td>Montenegro et al.</td>
<td>36</td>
<td>1 Year</td>
<td>Bicavera</td>
<td>NR</td>
</tr>
<tr>
<td>Szeto et al.</td>
<td>50</td>
<td>1 Year</td>
<td>Balance</td>
<td>↔</td>
</tr>
<tr>
<td>Kim et al.</td>
<td>91</td>
<td>1 Year</td>
<td>Balance</td>
<td>↔</td>
</tr>
<tr>
<td>Haag-Weber et al.</td>
<td>69</td>
<td>20 Months</td>
<td>Gambrosol Trio</td>
<td>↔</td>
</tr>
</tbody>
</table>

NR: not reported

• No recommendation can be made on the specific choice of PD solution to reduce peritonitis risk.

Infections associated with peritoneal dialysis

• Existing epidemiological data suggest that infection in dialysis populations is associated with a marked increase in the use of health-care resources, as well as excess morbidity and mortality

• patients undergoing PD or HD have a notably increased risk of infection, particularly peritonitis in the former group and catheter-related bloodstream infection in the latter group

Li PKT, Chow KM. Nature Reviews Nephrology 2012 (Feb); 8: 77-88
Change in adjusted all-cause & cause-specific hospitalization rates, by modality


USRDS data 2011
Infections associated with peritoneal dialysis

- Implementation of guidelines and protocols on prevention and treatment of PD related infections can result in improvement in the overall peritonitis rate and outcomes are possible

Li PKT, Chow KM. Nature Reviews Nephrology 2012 (Feb); 8: 77-88
Nephrology Division, Prince of Wales Hospital, Chinese University of Hong Kong