ERKNet/ESPN

Workshop on fundamentals in pediatric dialysis

21 - 22 October 2021

Peritonitis and Other Complications of Peritoneal Dialysis in Children

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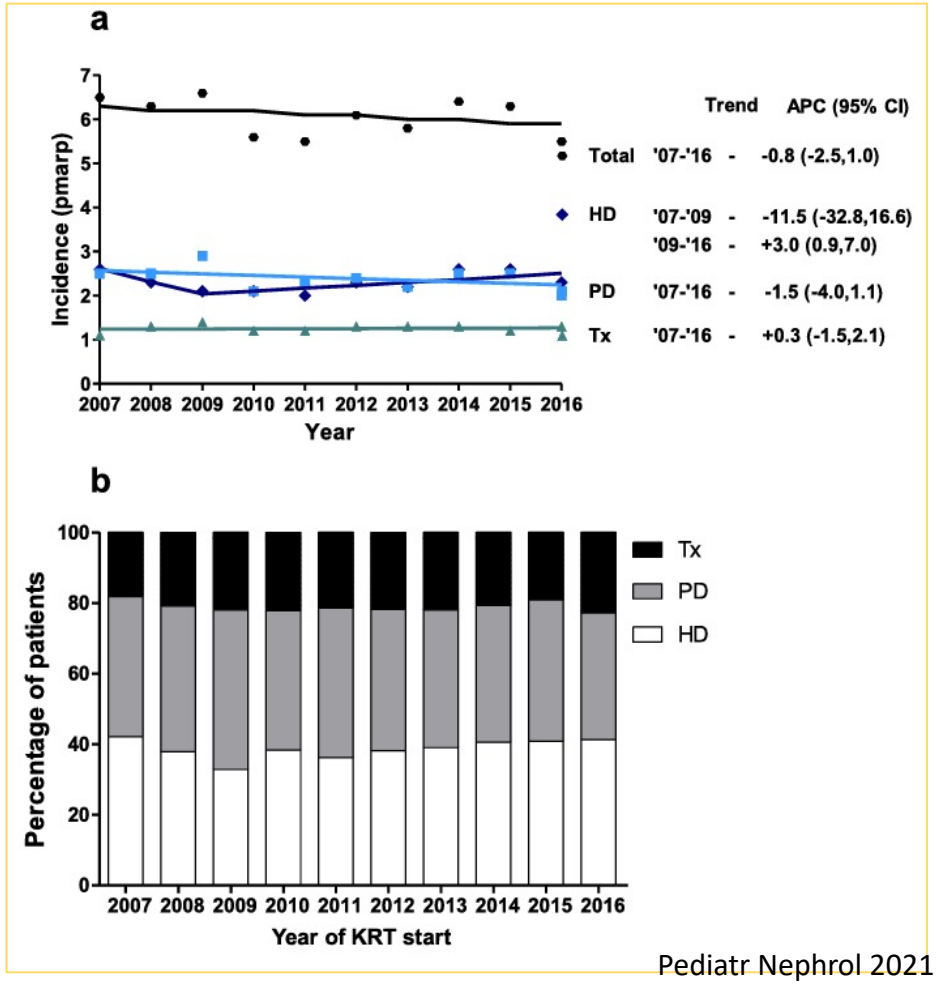
Ten-year trends in epidemiology and outcomes of pediatric kidney replacement therapy in Europe: data from the ESPN/ERA-EDTA Registry

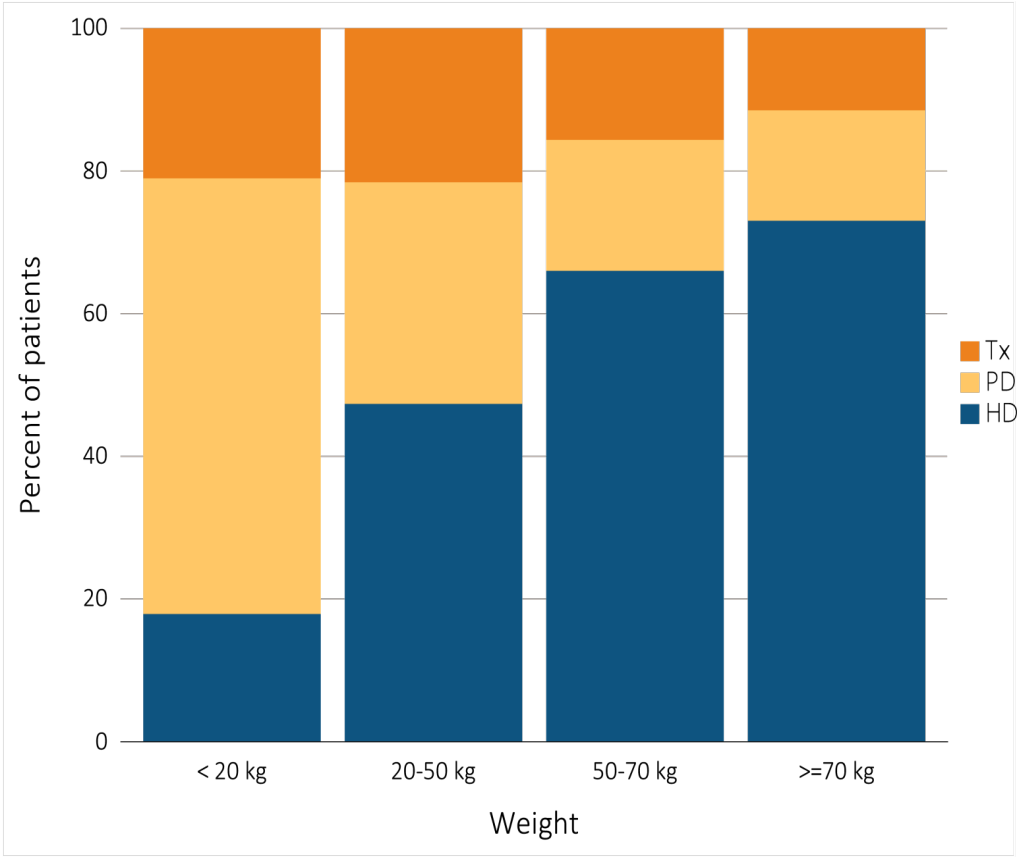
Marjolein Bonthuis[1] · Enrico Vidal[2] · Anna Bjerre[3] · Özlem Aydoğ[4] · Sergey Baiko[5] · Liliana Garneata[6] · Isabella Guzzo[7] · James G. Heaf[8] · Timo Jahnukainen[9] · Marc Lilien[10] · Tamara Mallett[11,12] · Gabriel Mirescu[13,14] · Elena A. Mochanova[15] · Eva Nüsken[16] · Katherine Rascher[17] · Dimitar Roussinov[18] · Maria Szczepanska[19] · Michel Tsimaratos[20] · Askiti Varvara[21] · Enrico Verrina[22] · Bojana Veselinović[23] · Kitty J. Jager[1] · Jérôme Harambat[24]



Pediatr Nephrol 2021

Trends in pediatric ESRD modality at initiation, by patient weight, 1996-2014

USRDS 2016 report



Complications of PD

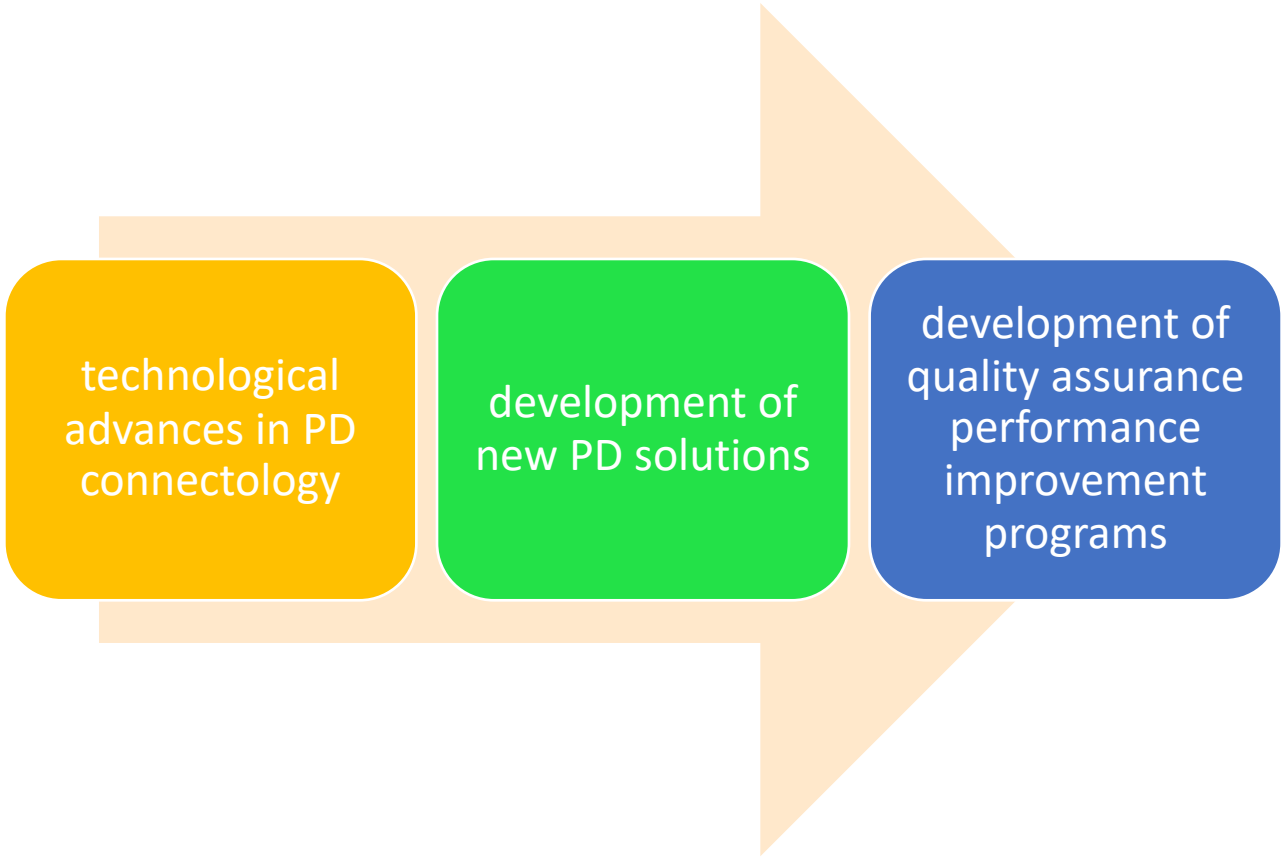
- **Infectious complications**
  - Peritonitis
  - Catheter-related infections
    - Exit-site infections
    - Tunnel infections
- **Noninfectious complications**
  - Mechanical
    - Leakage
    - Catheter migration
    - Cuff extrusion
    - Outflow obstruction
    - Hernias

Adequacy and ultrafiltration problems
Inadequate solute clearance
Poor compliance
Decreased peritoneal permeability
Inadequate ultrafiltration
Fast transport status
Encapsulated peritoneal sclerosis
Metabolic complications
Hyperglycemia
Hyperinsulinemia
Hypertriglyceridemia
Hypokalemia
Magnesium alterations

- **Other complications**

Hemoperitoneum
Pneumoperitoneum
Pancreatitis
Ischemic colitis and necrotizing enterocolitis

Bakkaloglu SA, Sethna C. Pediatric Dialysis 2021



Peritonitis remains the most common complication of CPD

Scan me!

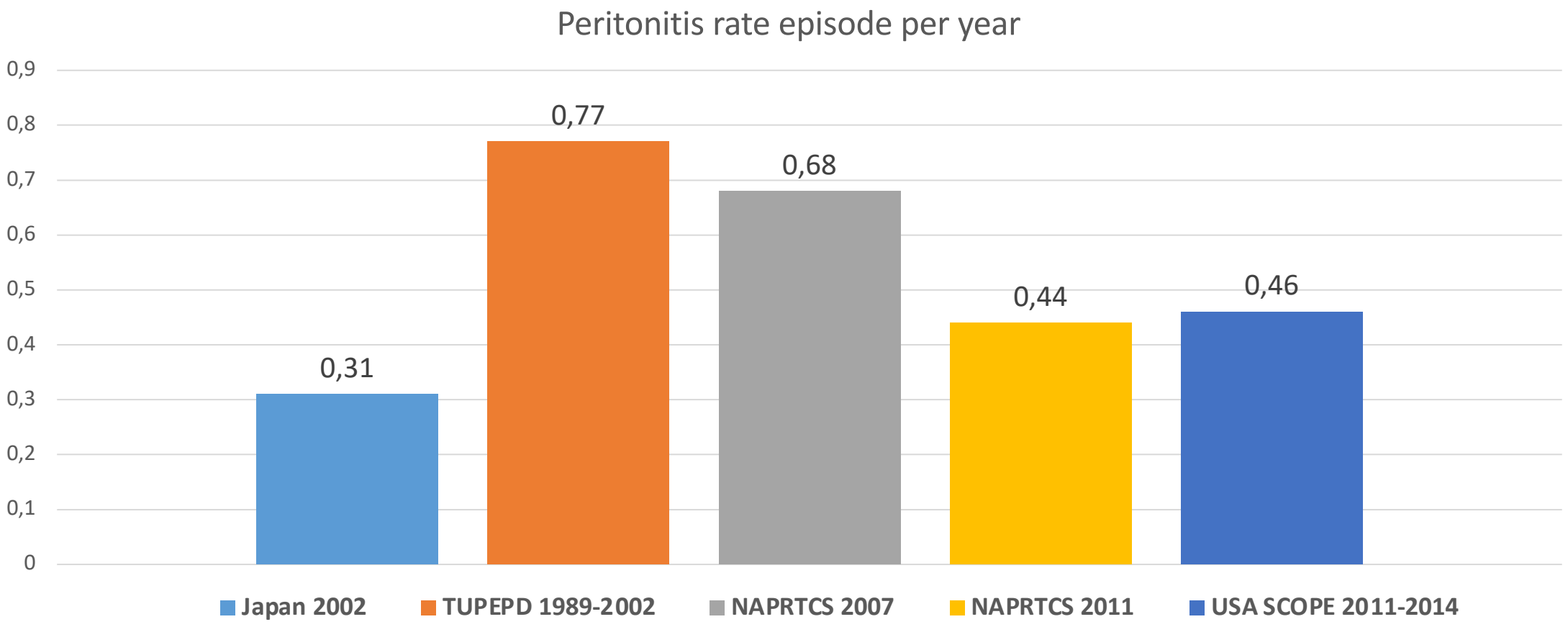
IPPN

NAPRTCS

USRDS

SCOPE

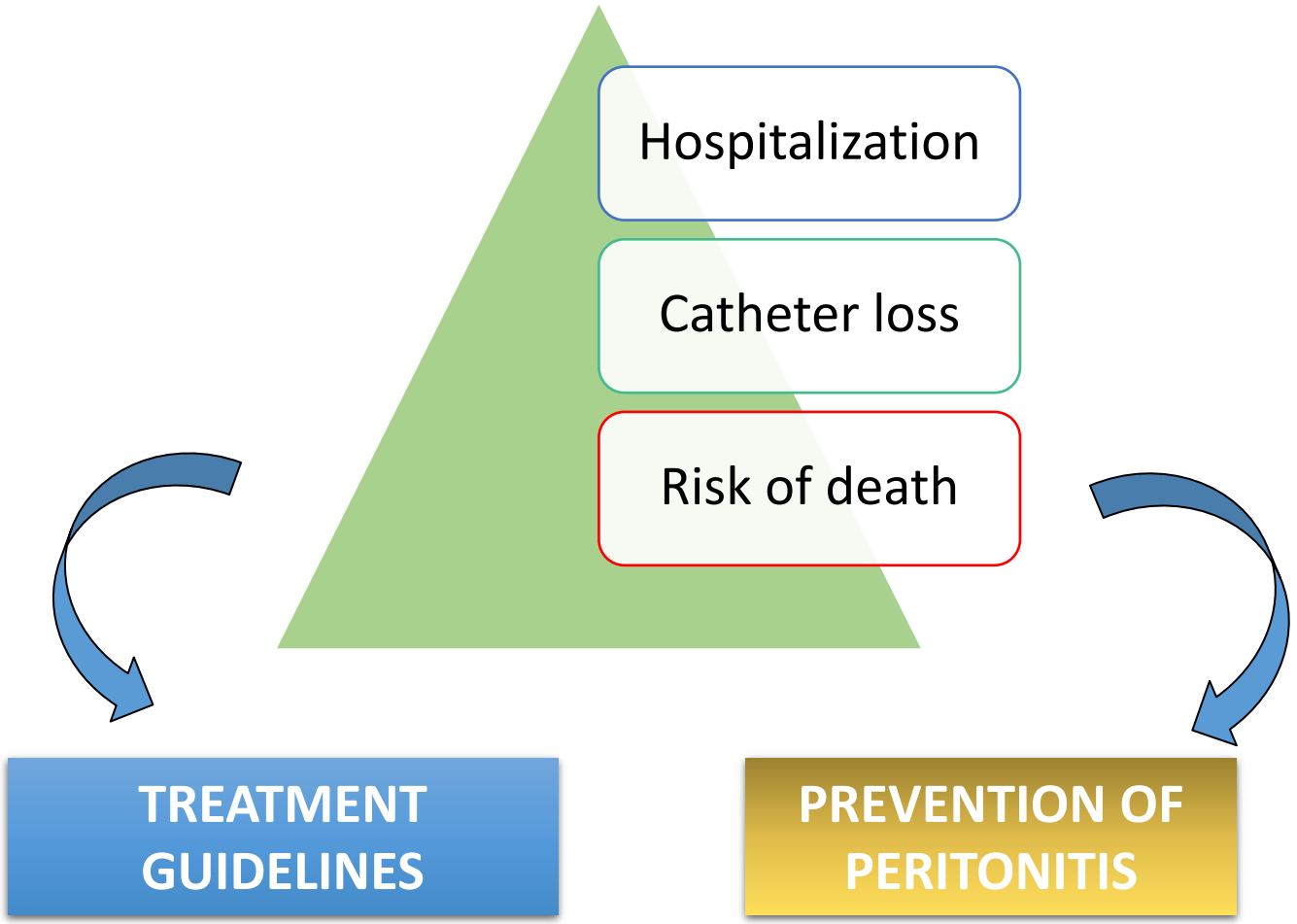
TSPN RRT



NAPRTCS 2011 - Significant improvement is seen since 2002 with the annualized rate of infection **decreasing from 0.79 in 1992-1996 to 0.44 in recent years**.

NAPRTCS 2007, Honda M, Proc Pediatr PD Conf 2002, Akman S, Pediatr Int 2009 ,
NAPRTCS 2011, Setha J, CJASN 2017

Peritonitis



NAPRTCS 2011 Report, USRDS 2013, 2016 Reports, cJASN 2017 (IPPN Report)

Prevention of Peritonitis

Catheter related interventions to reduce peritonitis risk

- Use double-cuff catheters
- Lateral/downward subcutaneous tunnel configuration

Antimicrobial prophylaxis

- Preoperative antibiotics at catheter insertion
- Exit site antimicrobial application
- Fungal prophylaxis

Prevention of contamination

- Experienced nursing personnel
- Long training period, retraining, home visits
- Avoidance of spiking technology
- Contamination protocols

Development of continuous quality improvement programs

- Tracking and questioning infectious episodes as well as causative agent
- Monthly team meetings (evaluation of root cause; plan to prevention of recurr.)
- Reevaluation of protocols of the PD program

Verrina et al, PDI; 2000;20:625-30, Bender FH, et al. KI 2006;70:S44-S54, Bakkaloglu SA 2009 PDI

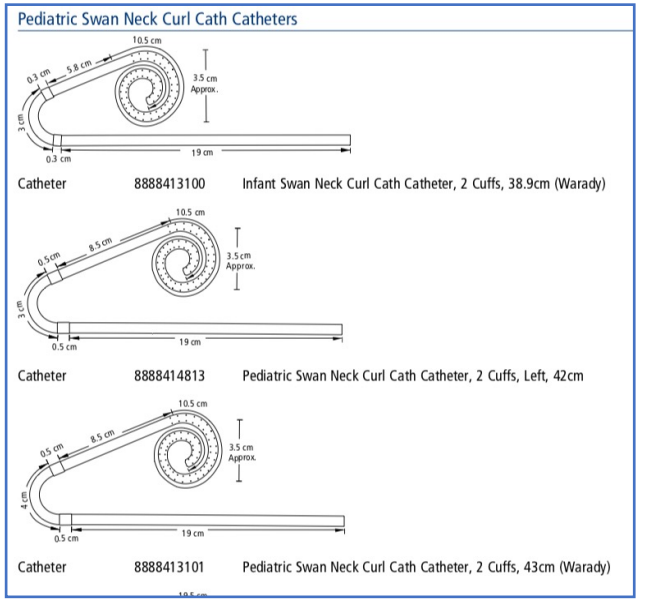
Prevention of Peritonitis

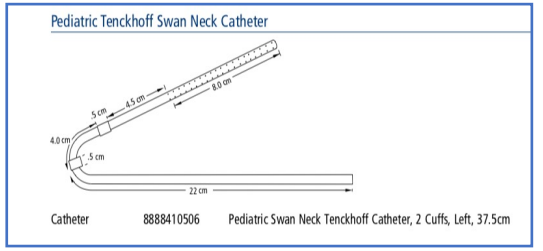
Catheter related interventions to reduce peritonitis risk

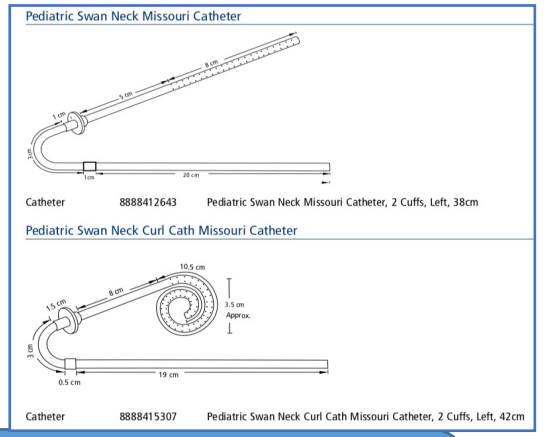
Use double-cuff catheters

Lateral/downward subcutaneous tunnel configuration

- Catheter selection
  - Straight vs coiled
  - Single cuff vs double cuff
  - Preformed curve (swan-neck) or straight tunnel
- Exit-site orientation
  - Lateral or downward
    - Subcutaneous burying
- Catheter insertion techniques
  - Blind percutaneous
  - Open surgical
  - Laparoscopic
  - Minilaparoscopic
  - Peritoneoscopic single trocar







No firm agreement on exact catheter type and configuration

No technique of PD catheter implantation that has consistently proven to be superior for the prevention of peritonitis

PD CATHETER SIZE

CENTER's SURGICAL EXPERTISE in the APPLIED METHOD

Locate superficial cuff 2 cm from the exit site

Use the smallest exit hole

No incision, no sutures at the exit site

Catheter anchoring and immobilization

Dressing changes should be avoided in the first week, then weekly up to 6 wk

If possible, do not use the catheter at least for two weeks

Verrina et al, PDI; 2000;20:625-30, Bender FH, et al. KI 2006;70:S44-S54, Bakkaloglu SA 2009 PDI, Neeu A et al. Peritoneal Dialysis 2021

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Risk factors for *Pseudomonas* peritonitis

- Use of saline or soap for cleansing
- Exit site care > twice per week
- Use of exit site mupirocin

Schaefer et al. Kidney Int 2007

ES Cleansing solutions

Povidone-iodin
Chlorhexidine solution
Amuchina solution/hypochlorite solution)

Topical antimicrobials

Mupirocin cream
Gentamicin cream or ointment
Ciprofloxacin otologic solution
Antibacterial honey
Polysporin triple ointment

Verrina et al, PDI; 2000;20:625-30, Bender FH, et al. KI 2006;70:S44-S54, Bakkaloglu SA 2009 PDI, Szeto CC, et al. PDI 2016

ISPD 2016 Adult guideline

- Daily topical application of antibiotic (mupirocin or gentamicin) cream or ointment to the catheter exit site is recommended

- Mupirocin resistance has been reported, particularly with intermittent use but not daily use

Bernardini J

Piraino B, et al. PDI 2016
Xu G, et al. Nephrol Dial Transplant 2010; 25:587–92.

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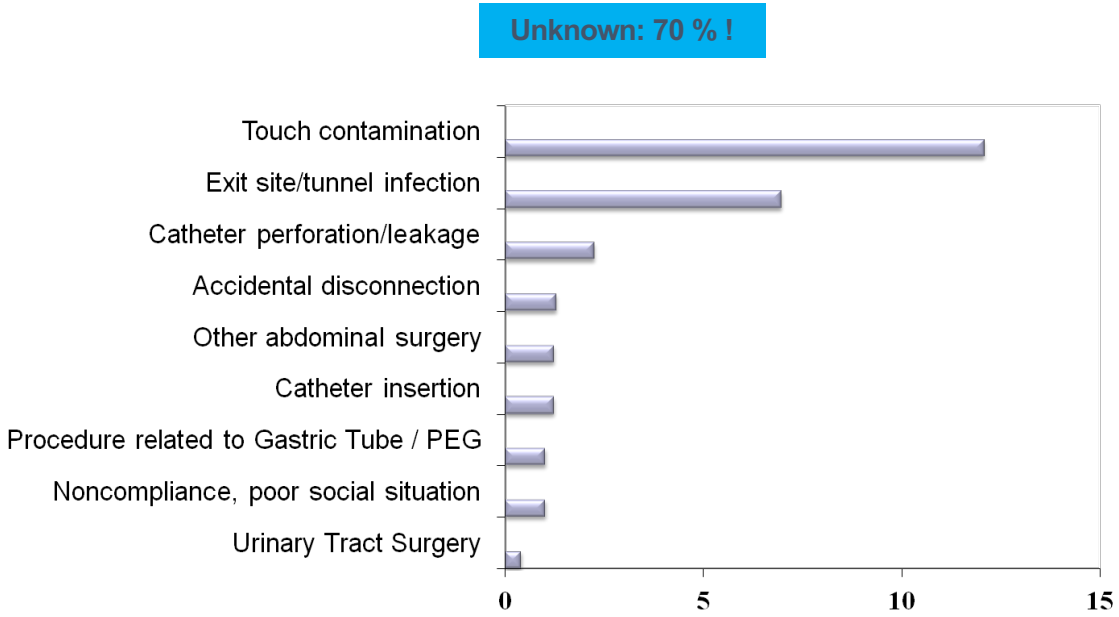
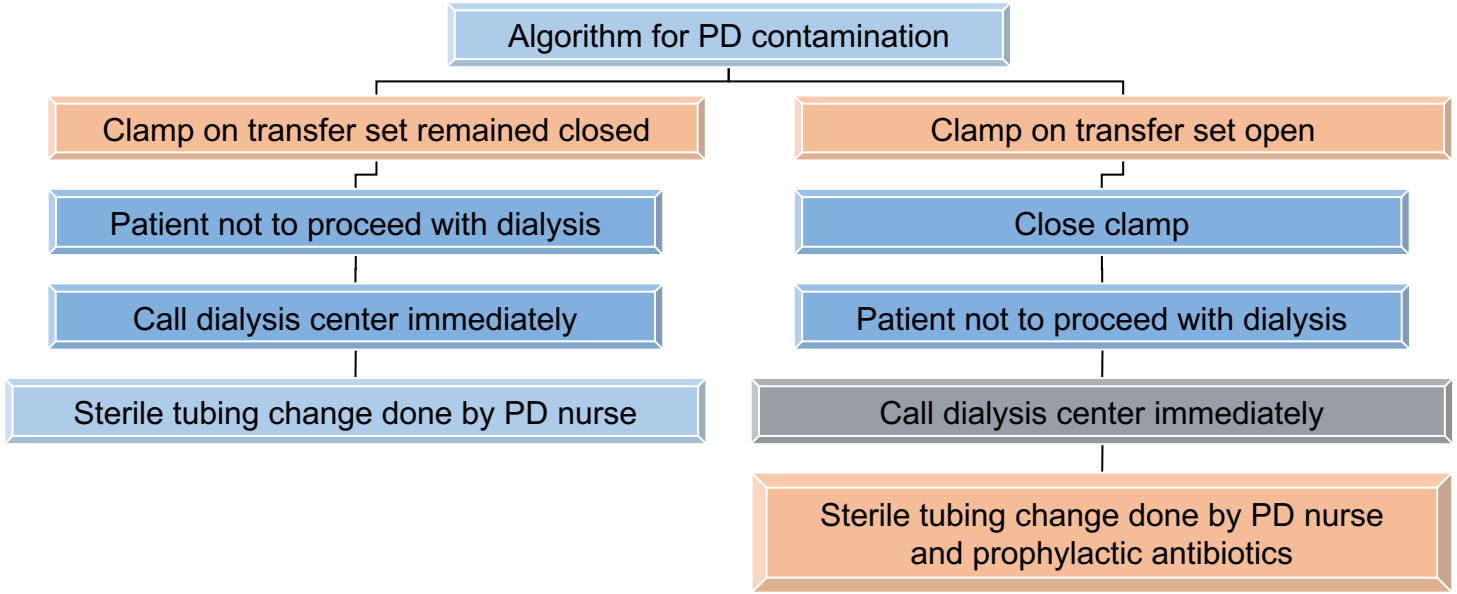
Peritonitis: Source of Infection





Verrina et al, PDI; 2000;20:625-30,

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SCOPE Collaborative – Standardized Care to Improve Outcomes in Pediatric End Stage Kidney Diseases

- Collaboratives
- Pediatric Quality Policy and Measures
- Partnerships
- Pediatric Quality Award
- Legacy Quality Programs
- Data Analytics & Research
- Peer Networking & Collaboration
- Pediatric Learning Solutions
- Group Purchasing & Supply Chain
- Insurance Services

The Standarized Care to Improve Outcomes in Pediatric Endstage Renal Disease (SCOPE) collaborative prevents infections in pediatric peritoneal dialysis and hemodialysis patients using large-scale collaboration to identify and spread effective interventions across pediatric care settings.

Focus

Peritoneal Dialysis (PD) — Preventing infections in PD patients reduces hospitalizations and allows patients to continue home-based dialysis and maintain normal school and family activities.

Hemodialysis (HD) – Similarly, preventing infections in HD patients reduces hospitalizations and the need for additional invasive procedures. Additionally, SCOPE is contributing to new knowledge

Impact

(as of July 2021)
PD - peritoneal dialysis; HD - hemodialysis

430 PD-related hospitalizations prevented

733 peritoneal infections prevented

Over **$12.9 million** saved hospitalization costs for PD-related infections and

Cherie Thomas
913-981-4199

Megan Esporas
919-484-9890

Scope Resources

- SCOPE Flyer
- SCOPE Teams
- SCOPE FAQs
- SCOPE Publications and Presentations

Scope Additional Resources

- SCOPE Enrollment Brief
- Enrollment Form
- SCOPE Charter
- SCOPE HD Charter
- SCOPE Enrollment Toolkit

CDC Partnership

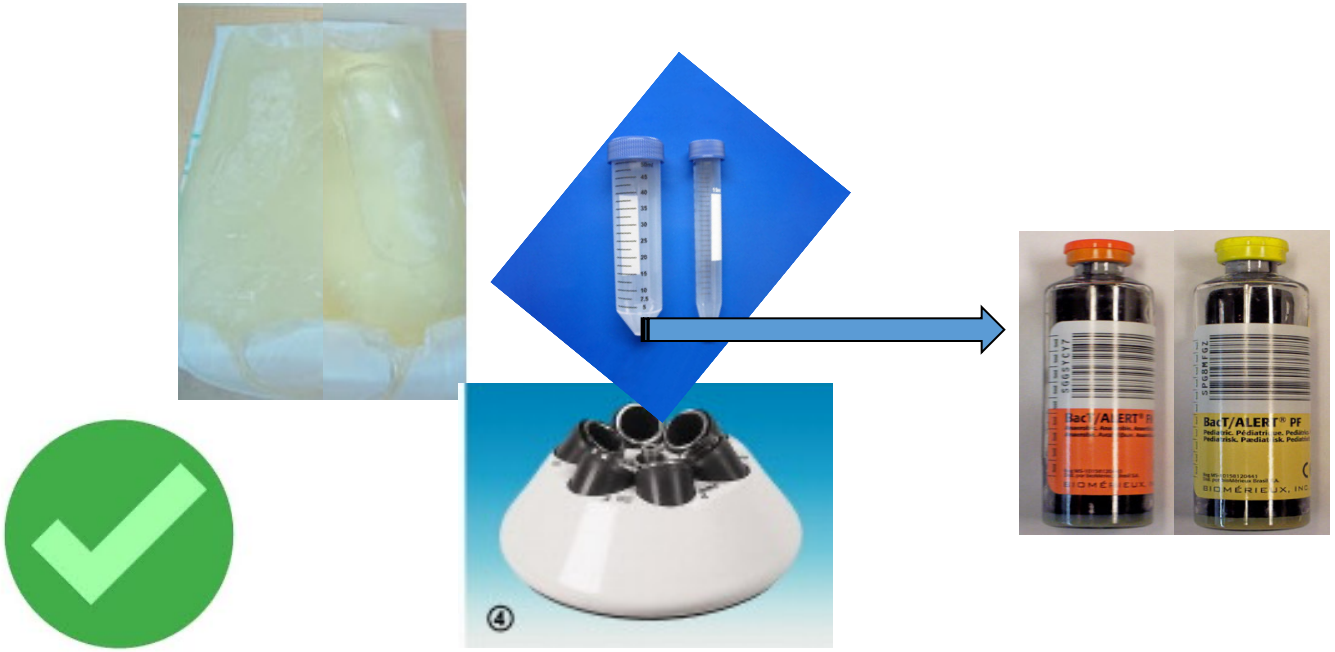
MAKING DIALYSIS SAFER FOR PATIENTS

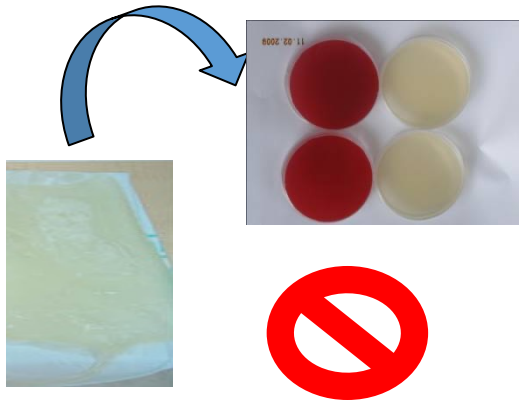
Peritonitis

- cell count
- differential count
- culture to confirm the diagnosis of peritonitis

- WBC> 100/mm^3, and at least 50% of the WBCs are PMNL

- centrifugation of PD effluent
- culture of sediment
- blood-culture bottles as the standard culture technique





Spectrum of Causative Organisms

	IPPR (501 episode)		IPPN (1456 episode)		SCOPE (389 episode)
Gram (+)	44%		63%		38%
Gram (-)	25%		33%		20%
Sterile	31%			33%	25%
Fungal		2%	4%		8%
Polymicrobial					10%

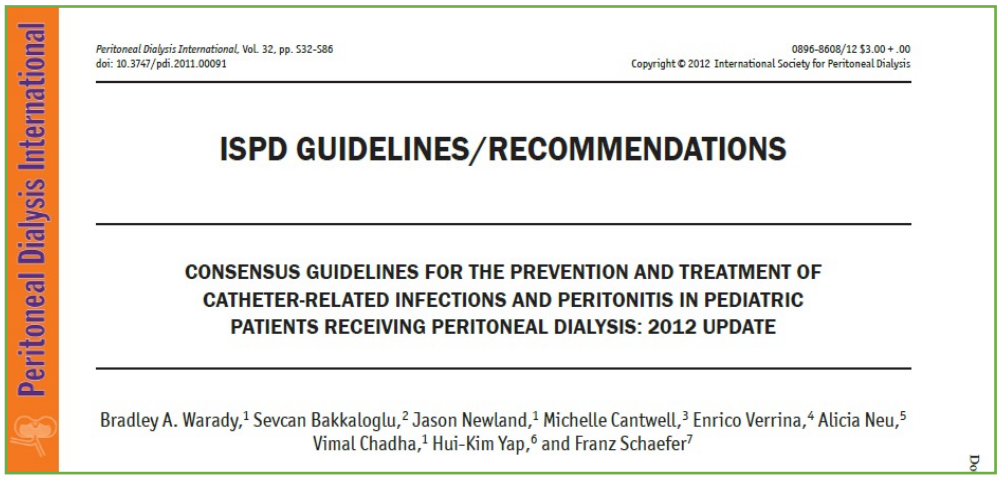
CNS	25%
S. auresus	22%
E.coli	8%
Streptococci	7%
Pseudomonas sp.	6%
Enterococci	6%

Geographic variability

Environmental – Humidity, climate

PD practice – ES care, topical antibiotic prophylaxis

Adapted from Neu et al. Pediatric Dialysis 2021



Peritoneal Dialysis International

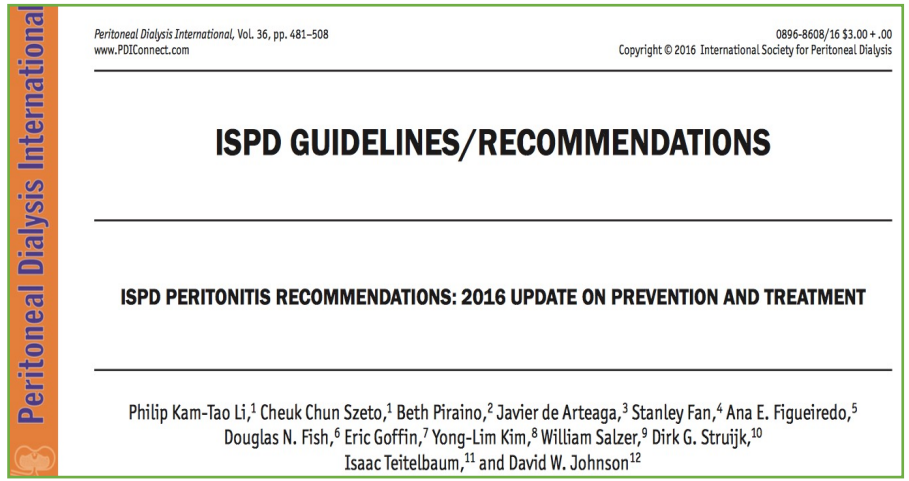
Peritoneal Dialysis International, Vol. 32, pp. 532–586
doi: 10.3747/pdi.2011.00091

0896-8608/12 $3.00 + .00

ISPD GUIDELINES/RECOMMENDATIONS

CONSENSUS GUIDELINES FOR THE PREVENTION AND TREATMENT OF CATHETER-RELATED INFECTIONS AND PERITONITIS IN PEDIATRIC PATIENTS RECEIVING PERITONEAL DIALYSIS: 2012 UPDATE

Bradley A. Warady,[1] Sevcan Bakkaloglu,[2] Jason Newland,[1] Michelle Cantwell,[3] Enrico Verrina,[4] Alicia Neu,[5] Vimal Chadha,[1] Hui-Kim Yap,[6] and Franz Schaefer[7]



Peritoneal Dialysis International

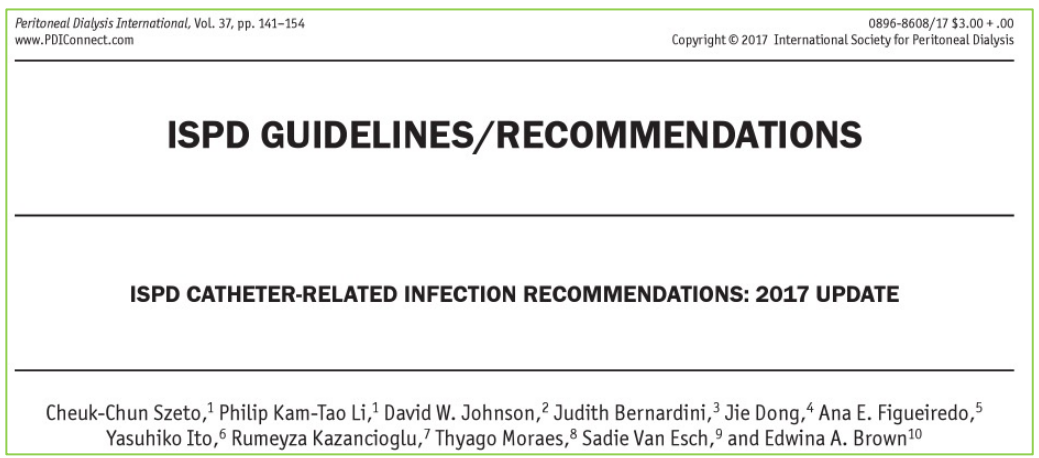
Peritoneal Dialysis International, Vol. 36, pp. 481–508
www.PDIConnect.com

0896-8608/16 $3.00 + .00

ISPD GUIDELINES/RECOMMENDATIONS

ISPD PERITONITIS RECOMMENDATIONS: 2016 UPDATE ON PREVENTION AND TREATMENT

Philip Kam-Tao Li,[1] Cheuk Chun Szeto,[1] Beth Piraino,[2] Javier de Arteaga,[3] Stanley Fan,[4] Ana E. Figueiredo,[5] Douglas N. Fish,[6] Eric Goffin,[7] Yong-Lim Kim,[8] William Salzer,[9] Dirk G. Struijk,[10] Isaac Teitelbaum,[11] and David W. Johnson[12]



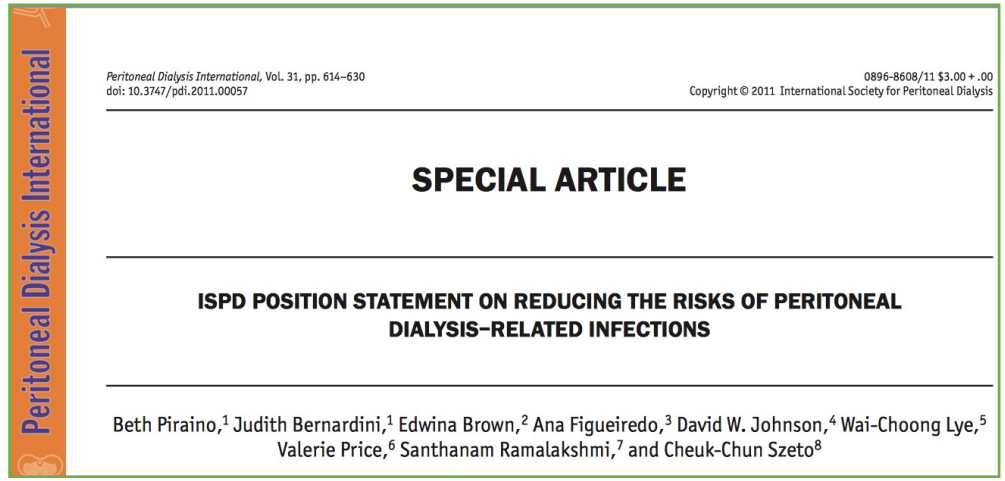
Peritoneal Dialysis International, Vol. 37, pp. 141–154
www.PDIConnect.com

0896-8608/17 $3.00 + .00

ISPD GUIDELINES/RECOMMENDATIONS

ISPD CATHETER-RELATED INFECTION RECOMMENDATIONS: 2017 UPDATE

Cheuk-Chun Szeto,[1] Philip Kam-Tao Li,[1] David W. Johnson,[2] Judith Bernardini,[3] Jie Dong,[4] Ana E. Figueiredo,[5] Yasuhiko Ito,[6] Rumeyza Kazancioglu,[7] Thyago Moraes,[8] Sadie Van Esch,[9] and Edwina A. Brown[10]



Peritoneal Dialysis International

Peritoneal Dialysis International, Vol. 31, pp. 614–630
doi: 10.3747/pdi.2011.00057

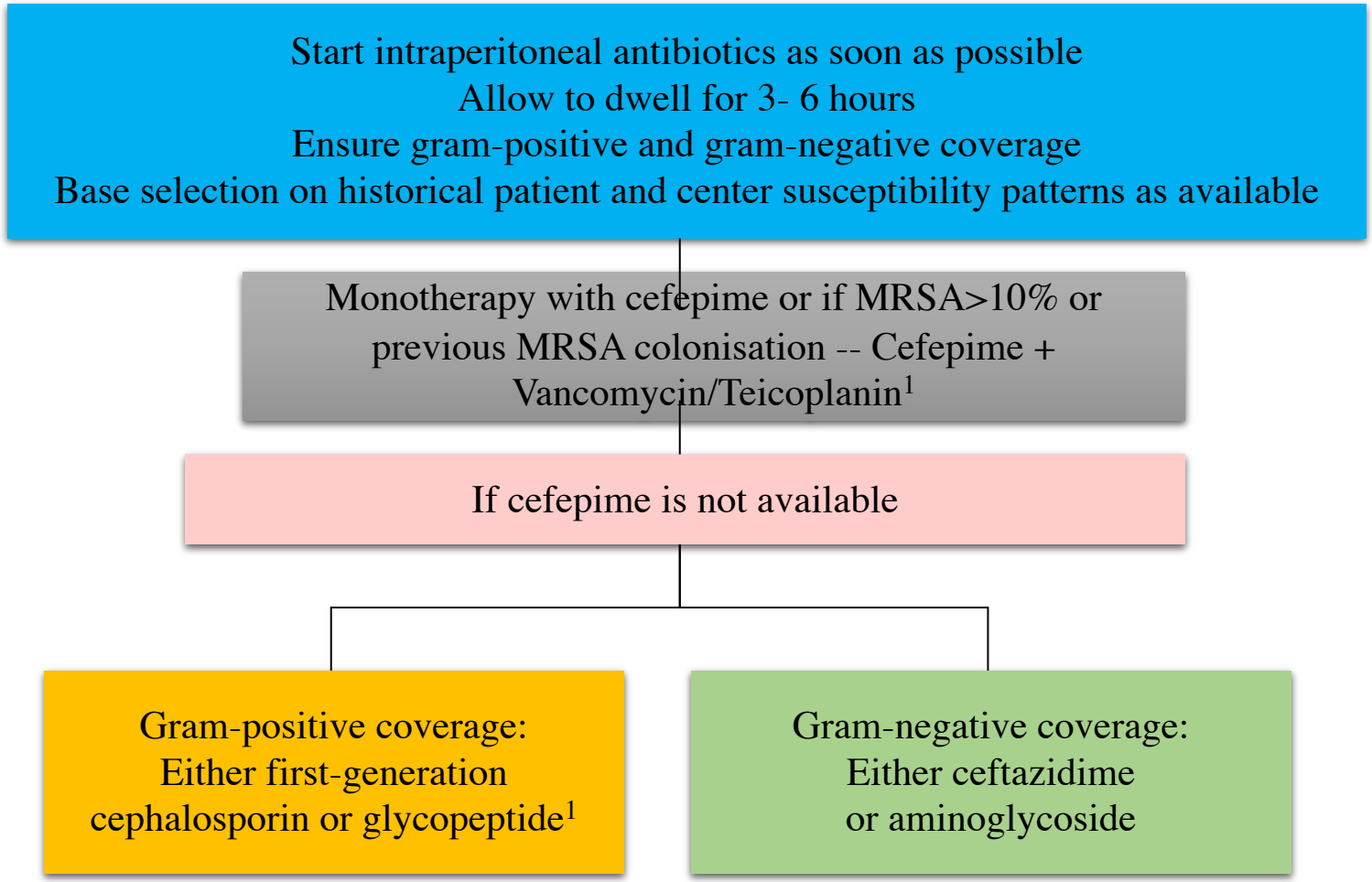
0896-8608/11 $3.00 + .00

SPECIAL ARTICLE

ISPD POSITION STATEMENT ON REDUCING THE RISKS OF PERITONEAL DIALYSIS–RELATED INFECTIONS

Beth Piraino,[1] Judith Bernardini,[1] Edwina Brown,[2] Ana Figueiredo,[3] David W. Johnson,[4] Wai-Choong Lye,[5] Valerie Price,[6] Santhanam Ramalakshmi,[7] and Cheuk-Chun Szeto[8]

Empiric antibiotic therapy



If the center's MRSA rate exceeds 10% or patient has history of MRSA colonization, glycopeptide (vancomycin / teicoplanin) should be added to cefepime or should replace the first generation cephalosporin for gram-positive coverage. Glycopeptide usage can also be considered if patient has a history of severe allergy to penicillins and cephalosporins.

Warady BA, et al. PDI 2012

	Continuous therapy		Intermittent therapy
	Loading dose	Maintenance dose	
Aminoglycosides[a]			
Gentamicin	8 mg/L	4 mg/L	anuric: 0.6 mg/kg non-anuric: 0.75 mg/kg.
Netilmycin	8 mg/L	4 mg/L	
Tobramycin	8 mg/L	4 mg/L	
Cephalosporins			
Cefazolin	500 mg/L	125 mg/L	20 mg/kg
Cefepime	500 mg/L	125 mg/L	15 mg/kg
Cefotaxime	500 mg/L	250 mg/L	30 mg/kg
Ceftazidime	500 mg/L	125 mg/L	20 mg/kg
Glycopeptides[b]			
Vancomycin	1000 mg/L	25 mg/L	30 mg/kg; repeat dosing 15 mg/kg every 3-5 days
Teicoplanin[c]	400 mg/L	20 mg/L	15 mg/kg q 5 – 7 days
Penicillins[a]			
Ampicillin	----------	125 mg/L	----------
Quinolones			
Ciprofloxacin	50 mg/L	25 mg/L	----------
Others			
Aztreonam	1000 mg/L	250 mg/L	----------
Clindamycin	300 mg/L	150 mg/L	----------
Imipenem/Cilastin	250 mg/L	50 mg/L	----------
Oral			
Linezolid	< 5 yrs: 30 mg/kg/day divided TID; 5-11 yrs: 20 mg/kg/day divided BID; ≥ 12 yrs 600 mg/dose BID		
Metronidazole	30 mg/kg/day divided TID		
Rifampin	10-20 mg/kg/day divided BID (max daily dose 600 mg)		
Antifungals			
Fluconazole	6 – 12 mg/kg IP, IV or PO every 24-48 hrs (max dose 400 mg)[#]		
Caspofungin	IV only: initial dose 70 mg/m^2 on day 1 (max dose 70 mg); Subsequent dosing 50 mg/m^2 daily (max dose 50 mg)		

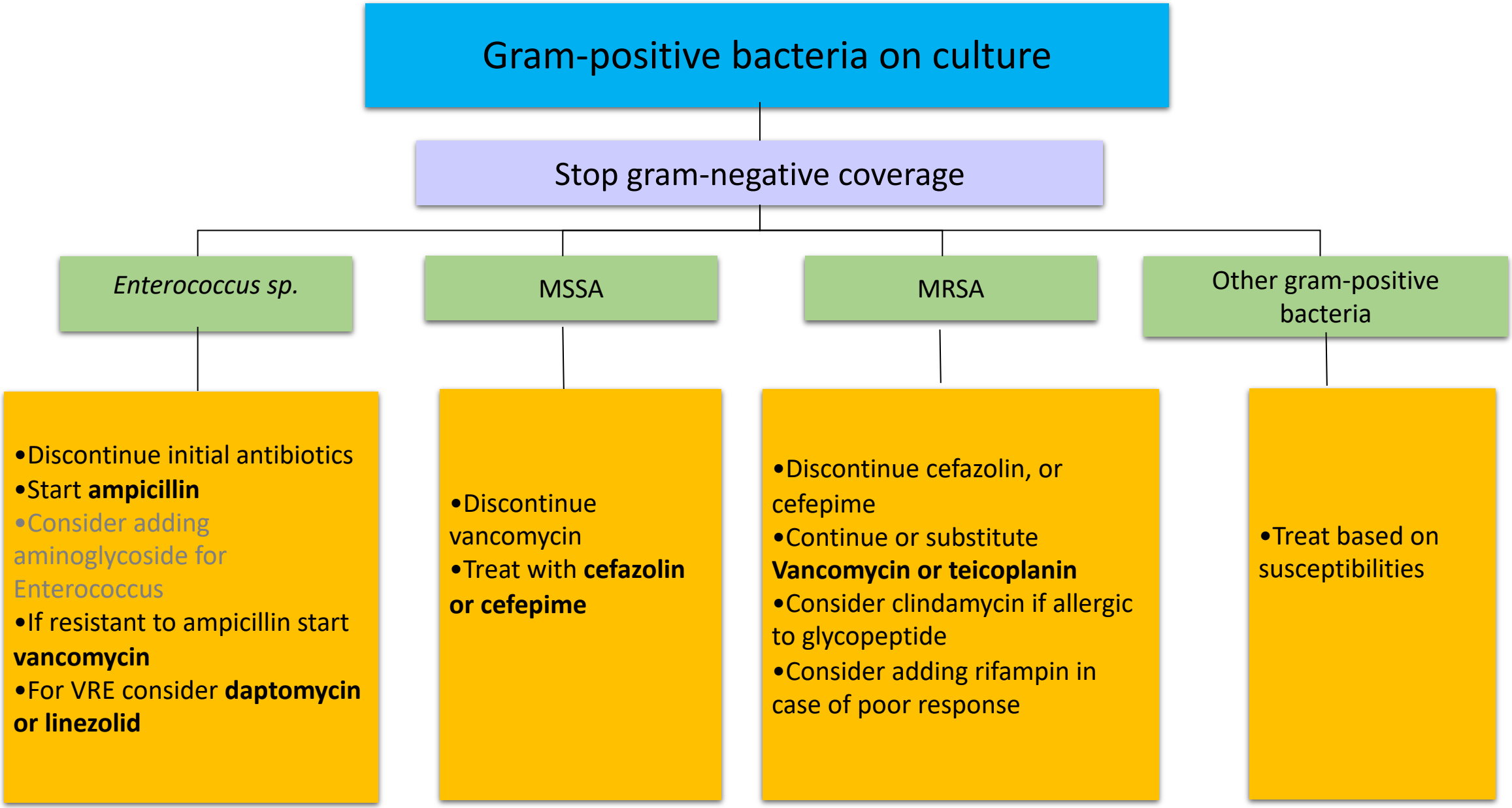


Figure 2. Gram-positive organism on culture. MRSA-methicillin resistant *S. aureus*; methicillin sensitive *S. aureus*; VRE-vancomycin resistant enterococci.

Gram-positive bacteria and the recommended antibiotics and length of therapy

	Recommended Antibiotic(s)*	Length of Therapy
Methicillin-resistant S. aureus	Vancomycin/Teicoplanin, Clindamycin	3 weeks
Methicillin-susceptible S. aureus	Cefazolin, Cefepime	3 weeks
Coagulase negative staphylococci	Vancomycin/Teicoplanin, Clindamycin if MR	2 weeks
Enterococcus sp.	Ampicillin, Vancomycin/Teicoplanin	2-3 weeks
Vancomycin resistant Enterococcus	Daptomycin, Linezolid	2-3 weeks
Streptococcus species	Ampicillin, Cefazoline, Cefepime	2 weeks

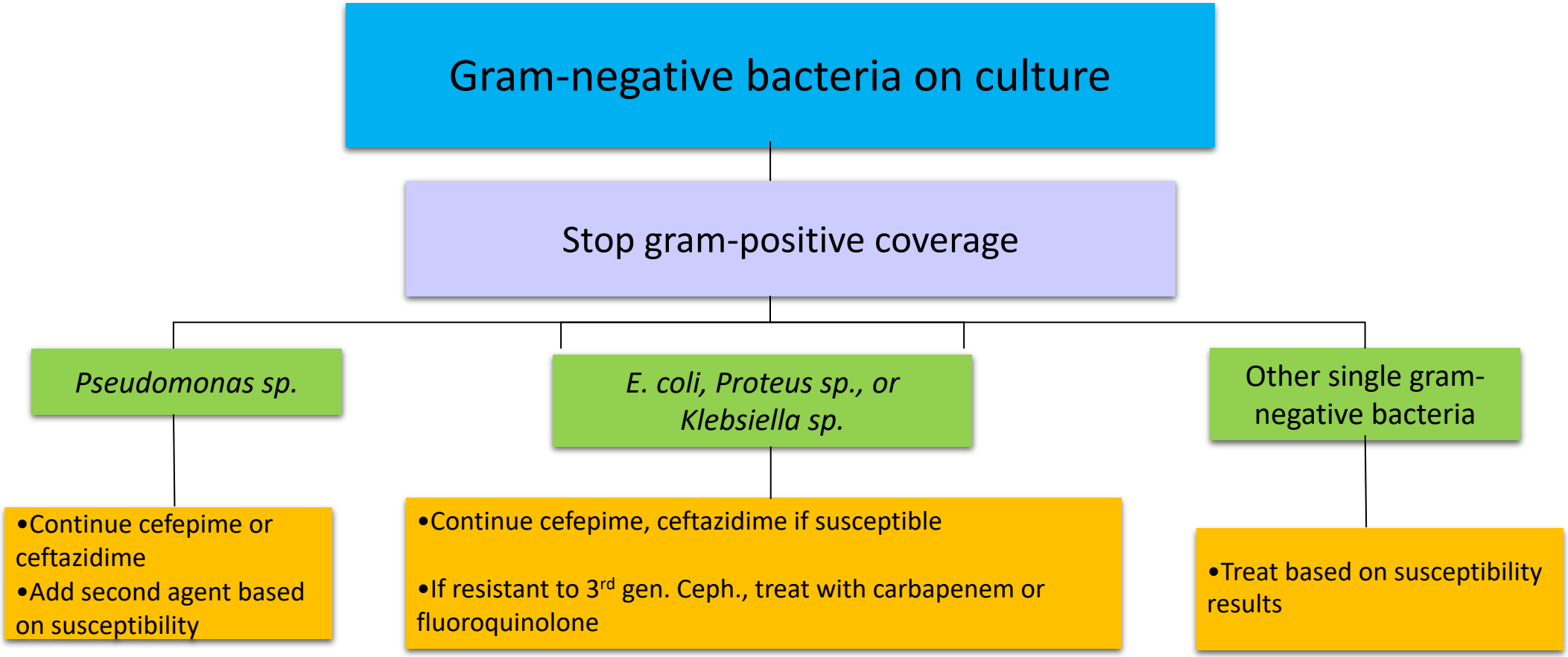


Figure 3. Gram-negative organism on culture

Gram-negative bacteria and the recommended antibiotics and length of therapy

Bacteria	Recommended Antibiotic(s)*	Length of Therapy
***E. coli*, Klebsiella sp.**	Cefazolin, Cefepime, Ceftazidime, Ceftriaxone/ Cefotaxime	2 weeks
E. coli, Klebsiella sp. resistant to 3rd generation Cephalosporins	Carbapenem** or Fluoroquinolone	3 weeks
Enterobacter sp., Citrobacter sp., Serratia sp., Proteus sp.	Cefepime, Ceftazidime or Carbapenem**	2-3 weeks
Acinetobacter sp.	Cefepime, Ceftazidime or Carbapenem	2-3 weeks
Pseudomonas species	Cefepime, Ceftazidime, Piperacillin or Ticarcillin, plus Aminoglycoside or Fluoroquinolone	3 weeks
Stenotrophomonas maltophila	Trimethoprim/Sulfamethoxazole, Ticarcillin/Clavulanic acid	3 weeks

Fungal peritonitis

- 2%-8% of all peritonitis episodes in children
- Risk factors
  - Prior antibiotic use
  - Gastrostomy ?
  - Antifungal prophylaxis during antibiotic usage in programs with high rates of fungal peritonitis

- If fungi are identified by Gram stain or culture of peritoneal effluent, therapy should consist of treatment with an antifungal agent and early catheter removal

- Following catheter removal, antimycotic therapy be administered for 2 weeks or longer following complete resolution of the clinical symptoms of infection

Treatment

- Fluconasole for Candida species
- Caspofungin for non responding non-albicans Candida
- Voriconasole for Asergillus

- Treatment duration following catheter removal should be 2 weeks or longer following complete resolution of the clinical symptoms of infection

  - Amphotericin B 
    - Poor peritoneal penetration
    - Intraperitoneal irritation and abdominal pain

Pediatr Nephrol (2015) 30:1397–1406
DOI 10.1007/s00467-014-2952-y

EDUCATIONAL REVIEW

Difficult peritonitis cases in children undergoing chronic peritoneal dialysis: relapsing, repeat, recurrent and zoonotic episodes

Sevcan A. Bakkaloglu · Bradley A. Warady

Relapsing peritonitis

Infectious locus poorly accecible te to antibiotics (catheter tunnel, fibrin, biofilm)
IPPR - 2.5-fold risk of permanent PD technique failure

While waiting in vitro susceptibility results, reinitiation of empiric therapy with consideration of the susceptibilities of the original bacteria

Postempyrically, choosing an antibiotic other than cefazolin
IP urokinase or t-PA

Remove the PD catheter as soon as peritonitis is controlled by antibiotic therapy in the setting of

- relapsing peritonitis associated with persistent or recurrent tunnel infection
- a second peritonitis relapse

Lane JC, et al CJASN 2010

Indications for catheter removal and replacement

Catheter removal		Reinsertion
	Refractory bacteria…	After 2-3 days
	Fungal …	After >2 weeks
	ESI/TI in … itis with the same organism (mainly, S… *P. aeruginosa*; except CNS)	After 2-3 weeks
Simultaneous removal and replacement of the catheter	Relapsing or refractory ESI/TI (including *P. aeruginosa*) Relapsing peritonitis	
Relative indications for removal	Repeat peritonitis	After 2-3 weeks
	Peritonitis with multiple enteric organisms due to an intra-abdominal pathology/ abscess; so-called surgical peritonitis	Dependent upon the clinical course of the patient ; at least 2-3 weeks

Save the peritoneum not save the catheter!

Exit-site / Tunnel infections

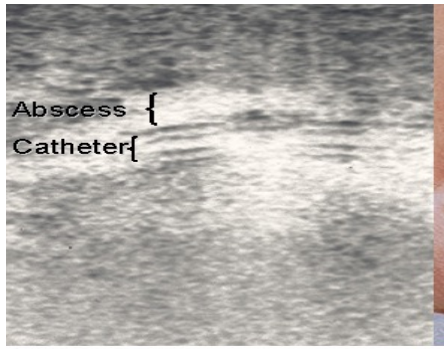


Photo courtesy of JA Diaz-Buxo

Photo courtesy of ZJ Twardowski

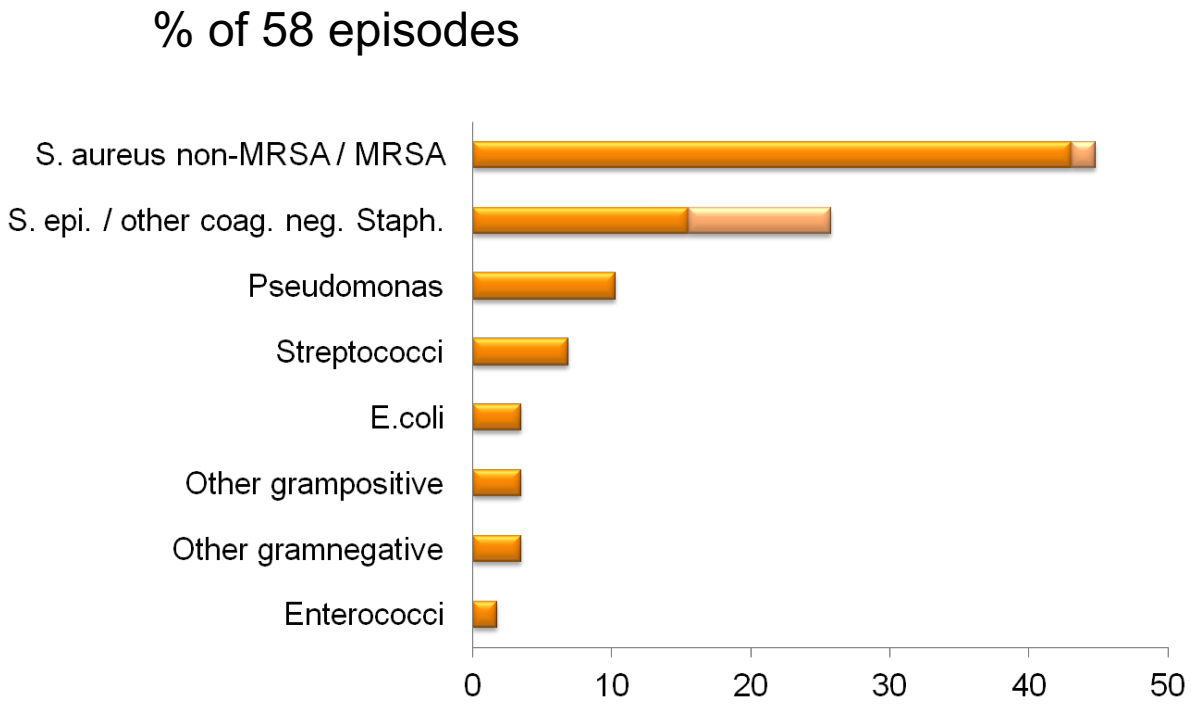
Exit-site scoring system

	0 Points	1 Point	2 Points
Swelling	No	Exit only (< 0.5cm)	Including part of or entire tunnel
Crust	No	< 0.5cm	> 0.5cm
Redness	No	< 0.5cm	> 0.5cm
Pain on pressure	No	Slight	Severe
Secretion	No	Serous	Purulent

For ESI exit-site score should be 4 or greater with or without positive culture (2 or greater if culture is positive)
For TI exit-site score should be 6 or greater with or without purulent drainage

Schaefer et al., J Am Soc Nephrol 1999

Causative Organisms at Exit Site



Scahefer F, Orlando 2008

Catheter-related peritonitis - IPPR

2-fold risk of peritonitis treatment failure

3-fold risk of catheter exchange

Schaefer et al. Kidney Int 2007

Treatment of Exit-site / Tunnel Infections

- Exit-site infections:
  - Oral antibiotic therapy when culture results and susceptibilities available
  - Gram positive usually penicillinase-resistant penicillin or cefalexin
  - Gram negative IP ceftazidime, combination therapy for Pseudomonas
  - a minimum of 2 weeks (3 weeks for *S. aureus* and *P. aeruginosa,* max 4 weeks)
  - at least 7 days following complete resolution of the infection

Tunnnel infections:

- Antibiotic therapy after culture and susceptibility results have been obtained
- Signs of severe infection, and/or a history of S. aureus or P. aeruginosa initiation of empiric therapy should be considered
- Oral, intraperitoneal or intravenous routes
- MRSA IV Glycopeptide
- Treatment duration should be 2-4 weeks

Oral antibiotics used in exit-site and tunnel infection

Antimicrobial	Dose	Frequency	Max/dose
Amoxicillin	10-20 mg/kg/day	Daily	1000 mg
Cephalexin	10-20 mg/kg/day	Daily or BID	1000 mg
Ciprofloxacin	10-15 mg/kg/day	Daily	500 mg
Clarithromycin	7.5 mg/kg/day	Daily or BID	500 mg
Clindamycin	30 mg/kg/day	TID	600 mg
Dicloxacillin	<40 kg 12.5-50 mg/kg/day > 40 kg 125-500 mg/dose	QID	500 mg
Erythromycin (as base)	30-50 mg/kg/day	TID or QID	500 mg
Fluconazole	1.5-3 mg/kg/day	Every 24-48 h	200 mg
Levofloxacin	10 mg/kg x 1 day, then 10 mg/kg/day	Every 48 h	Day 1 500 mg, then 250 mg
Linezolid	< 5 yrs 10 mg/kg/dose 5-11 yrs 10 mg/kg/dose > 12 yrs 600 mg/dose	TID BID BID	600 mg
Metronidazole	30 mg/kg/day	TID	2000 mg/day
Rifampin*	10-20 mg/kg/day	BID	600 mg
Trimethoprim/Sulfamethoxazole (based on TMP)	5-10 mg/kg/day	Daily	80mg

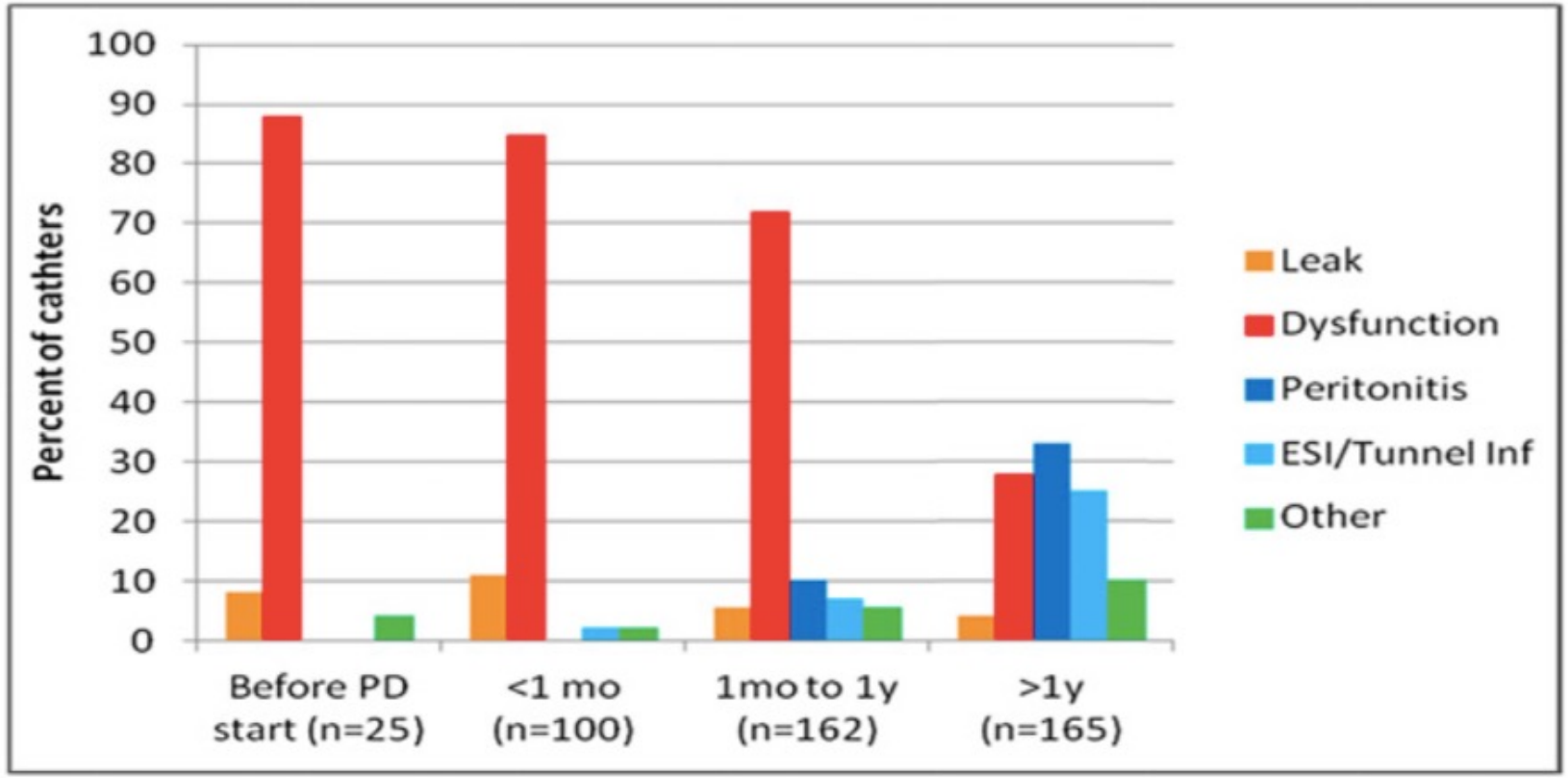
Noninfectious complications of peritoneal dialysis

Mechanical complications

- inflow/outflow problems
- catheter malposition
- pericatheter leak
- hernia

- Children under 2 years of age or weighing less than 10 kg are at a higher risk of these complications

2453 patients - 452 PD catheter revision (2007-2015)



Mechanical catheter related problems (malfunction and leakage) doubled the risk of technique failure compared with infectious causes

Infants: **More mechanical complications**
Short catheter survival

Borzych-Duzalka D, et al. Clin J Am Soc Nephrol 12: 105–112, 2017

	Rinaldi [8]	Rahim[29]	Donmez [30]	Macchini [31]	Aksu[10]	Stringel [22]	Hooman [38]	Ladd[19]	Vidal[7]	Phan [16]
Publication year	2004, Italy	2004, USA	2005, Turkey	2006, Italy	2007, Turkey	2008, USA	2009, Iran	2011, USA	2012, Italy	2013, USA
Study period	1986-2000	1990-2000	1997-2004	1986-2002	1995-2005	-	1993-2006	1986-2008 Retrospective, single center,	1995-2007, Registry data,	1994-2009, Retrospective, single center
Number of patients	363 (503 catheters)	90 (127 catheters)	53 (72 catheters)	78 (89 catheters)	93 (108 catheters)	21	122	163	84	207
Age	<15 years	0-21 years	3 days - 19 years		3 months-16 years	3 months-16 years	<14 years	Mean: 6.25 ±5.58 years.	All are infants started dx <1 years	Median: 12 (range: 0-21) years
Insertion technique	Surgical, omentectomy in 82.4%		Percutaneous Surgical Laparoscopic	Open surgical + omentectomy in 70%	Percutaneous	Laparascopic + omentectomy	Surgical	All open but 1% laparoscopic, 53% partial omentectomy	Open surgical + omentectomy (97%)	Mainly open, (laparoscopic in 9%) + partial or total omentectomy in 75%
PD modality		CCPD	CAPD	CAPD/CCPD	CAPD/CCPD	-	CAPD	CPD and acute (15% idiopathic acute renal failure)	CPD (70% APD 30% CAPD then APD)	CPD
Catheter type	Mainly double cuff staright		Mainly double cuff swan neck-curled and straight	Mainly double cuff straight	Double cuff swan neck curled	Single cuff curled, downward or lateral exit-site	Double cuff straight or swan neck curled	Curl or staraight Quinton catheters	Mainly double cuffed, curled, downward pointing exit-site	Mostly curled
Timing of catheter use		Early vs late	Early vs late		Early vs late	After one week	Early vs. late	-		
Hernia			15.1%	1.5%	No		20%			33% for patients <1 year vs 10% for those >1 year
Leak	5.8%	14.2%	41.5%	2.5%	no	Several minor leaks	15%	13%	3	18% for patients <1 year vs 3% for those >1 year
Kink					7%					
Dislocation	5.8%			3.5%	12%			11%	6	
Malfunction (obstruction, drainage problems)	5.3%	21.3%	20.8%	5%	7%	7 catheter		36%	9	
Cuff extrusion	4.8%		5.7%						3	
Catheter exchange	7.6% (38 catheters (17 obstruction, 14 dislocation, 4 cuff extrusion, 3 leakage)	Catheter malfunction in 11.8% of the patients, leak with infection in 1.6%	39.6% (21 catheters from 20 patients, malfunction in 11 patients and leak in 9 patients)	7.9% (7 catheters (6 dislocation, 1 obstruction))	12% (13 catheters from 11 patients (malfunction in 6, dislocation in 3, omental capture in 2, kink in 2))	7 interventions in 5 patients (24%) due to adhesions	Catheter obstruction in 8.7% of the patients	63 (39%) underwent catheter revision (obstruction in 23, leak in 8, malposition in 7)	Catheter replacement in 15% of cases, all mechanical complications. 21 catheters were repositioned, due to NI complication	46 (22%) catheters were removed for malfunction 34% adhesions, 24% leak, 17% fibrin plugs, 17% migration, and 8% other reasons

	Kim*[3]	Carpenter [13]	Radtke [12]	Borzych-Duzalka [9]	LaPlant[14]	Radtke[15]	Imani[18]	Nikibakhsh[20]
Publication year	2015, Korea	2016; USA	2016, Germany	2017, International	2018, USA	2018, Germany	2018, USA	2018, Iran
Study period	1986-2012, Retrospective, single center	2002-2014, Retrospective, single center	2009-2014 Retrospective, single center	2007-2015 Registry data International	2005-2017, Retrospective Two centers	2009-2015 Retrospective Two centers	Retrospective, single center, 2002-2015	2005-2011, Retrospective, single center
Number of patients	60 patients (70 catheters)	116 patients, 173 catheters	60 (71 catheters)	2453 (824 incident, 1629 prevalent)	130 patients, 157 catheters	122 patients, 154 catheters	25 catheters, only < 2yrs	56
Age at dialysis initiation	9.9±5.5 (at dx initiation)	9.7±6.3 years (2 days to 22 years)	Median: 3.3 (0.01–15.5) years	Median 10.5 (IQR: 3.4–14.2) years	4±5.3 years (1 day to 23 years)-46% infants	Median: 3.0 (0.01–17.1) years)	Median: 18 (7– 121) days, 60% neonate	Median: 6.5 y (1 mo – 14 years)
Insertion technique	-	Open (122) and laparoscopic (51) ± partial omentectomy (34%)	Open surgical	All	Mainly open and laparoscopic (n=20, 13%) + omentectomy	Open ± partial omentectomy	Laparoscopic (84%) ± omentectomy (40%)	Open surgical ± omentectomy
PD modality	CAPD	All CPD	33 CPD, 37 acute	Chronic PD	Acute and CPD	89 catheters for CPD, remaining for acute use	CPD	Acute (21) and CPD (35) (>3 weeks on PD)
Catheter type	Two-cuffed straight Tenckhoff, downward-pointing ES	Double cuffed catheters	One cuffed	All types	Argyle curl catheters (no straight tunnel) Upward pointing ES	One/double-cuffed curled, and straight catheters in small children (n =19), downward ES	One/double (29%)-cuffed curled (48%), and straight catheters	Swan neck coil two cuff
Timing of catheter use				Immediately, <7 day, ≥7 day	Same day and later on --22% delayed use		use within 3 days (48%)	Immediate use
Hernia	hernia (8.6%),				10% 15% in infants, and 5% in older children		20% hernia at catheter insertion (60% of newborns)	
Leak	leakage (10.0%),		7.1% (only in <10 kg)	29 (%1)	14% 21% leakage for infants vs 8% for others	18 (11.7% of catheters) (25.5% for pts<10 kg vs 5.6% for pts>10 kg)	32% (71% of newborns)	5.35%
Dislocation	catheter tip migration (2.9%),	7% (15% for pts < 2 y vs 5% for those >2 y	10%		6%	16 (10.4% of the catheters)	18%	
Malfunction (obstruction, drainage problems)	outflow failure (14.3%),	24% (including leak and kink)	12.9%	270 (%11)	6% - adhesion	31 (20.1% of catheters) (15 - omental trapping)	26%	21.4%
Catheter exchange	catheter malfunction, injury and oozing resulted in catheter removal in 7 (11.6%) patients – catheter exchange rate is 7.1% (n=5)	34% of the patients had their catheter exchanged due to NI causes (dysfunction more in children < 2 years)	17 out of 70 catheters (24.3%) needed a surgical revision within 6 months after implantation	catheter malfunction and leakage resulted in catheter exchange in 7.8% of the pts (n=192)**	17% of the patients had their catheter exchanged (8 for leakage, 3 migration, 1 adhesion, 1 hernia)	53 (34.4%) catheters underwent revision	18 new catheters (72%) were inserted within 12-mo follow-up	8.3% of CPD patients transferred to HD. NI complications are same with immediate use.

Catheter malfunction-obstruction: 5-36% in large pediatric series (44%- in infants only)

Inflow problems – soon after placement

- intraluminal catheter occlusion (often by thrombus and fibrin)
- Catheter kinking
- Migration

Outflow failure

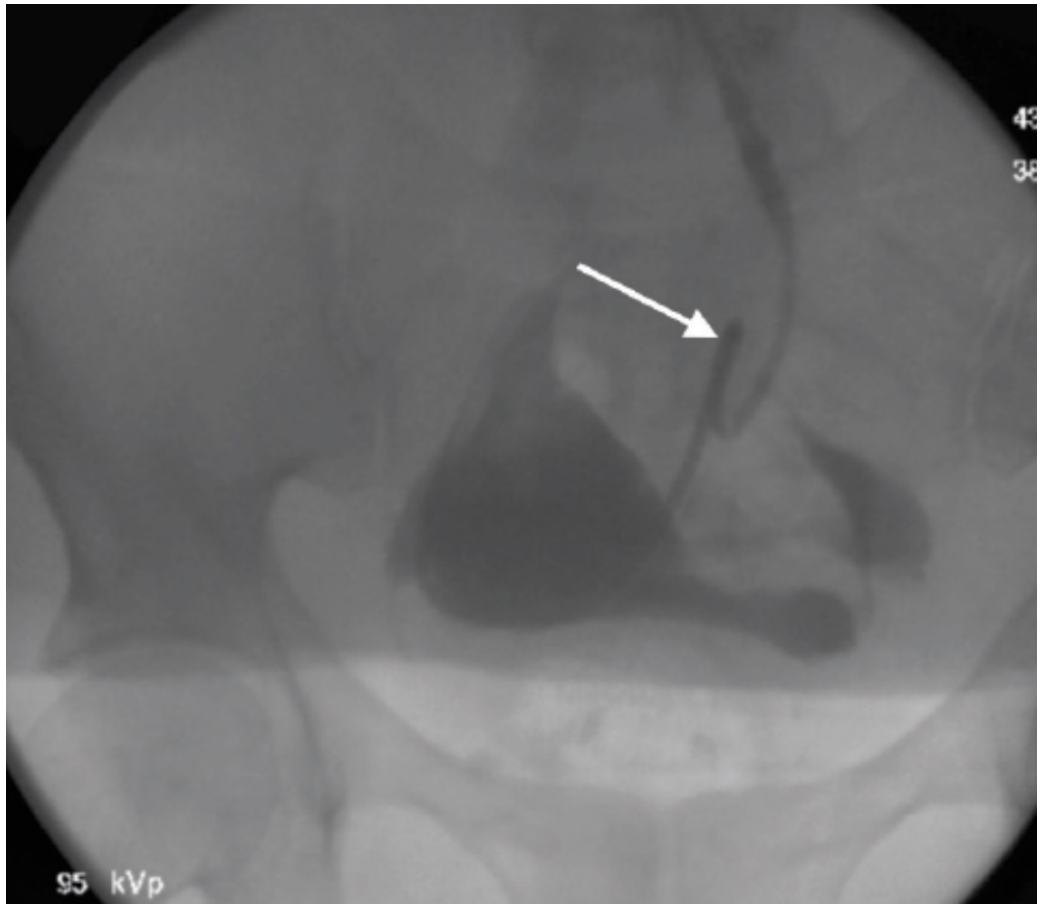
- constipation
- catheter malposition, tip migration
- intraluminal catheter occlusion (often by thrombus and fibrin)
- extraluminal catheter occlusion (by omentum, adhesions, epiploid fat appendices, fallopian tubes)
- catheter kinking

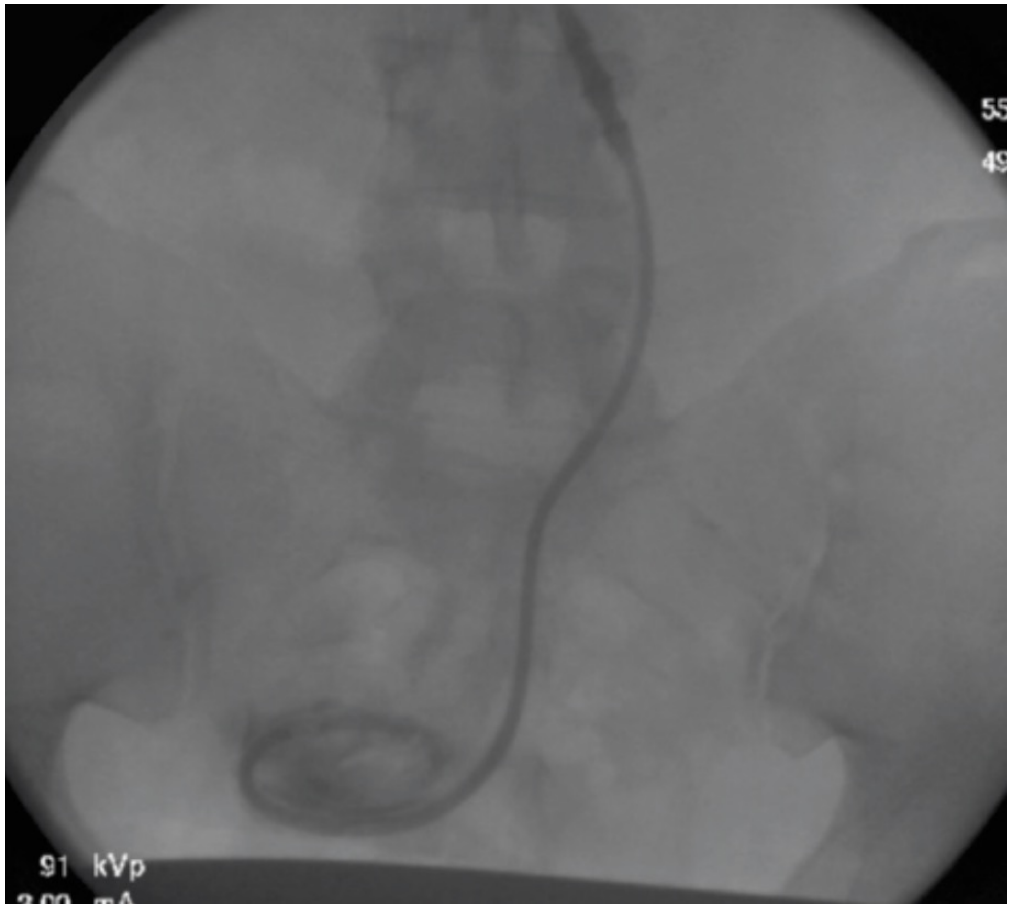
Prevention

- Avoid constipation by diet
- Enema, laxatives
- Saline flushing
- Cath related intevention?

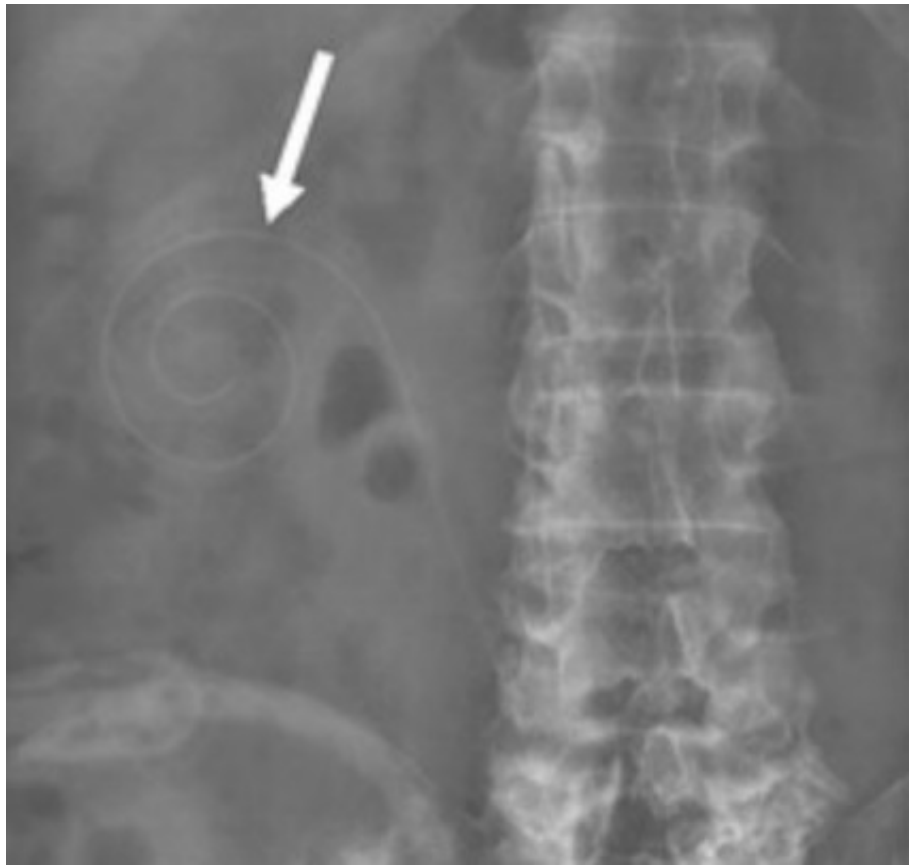
Surgical expertise with the applied implantation method appears more important for preventing short and long term catheter complications than the catheter type, design or implantation technique

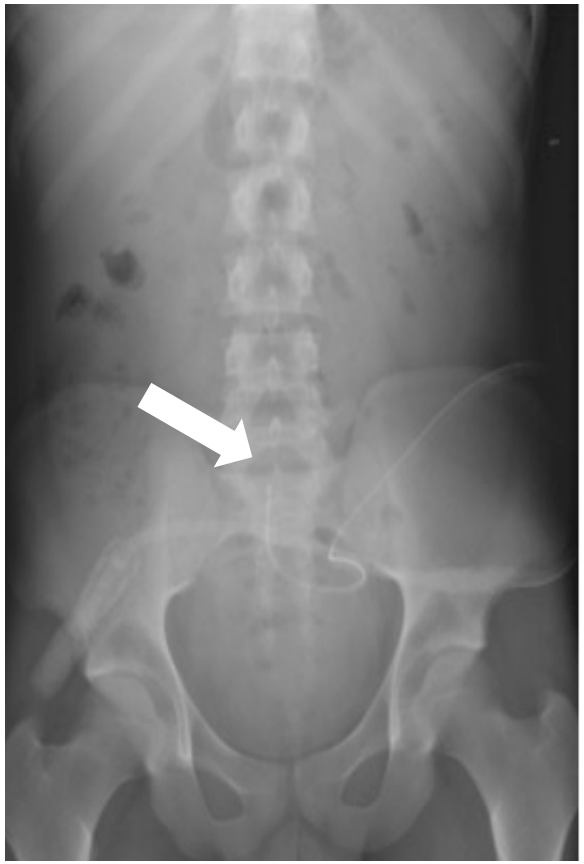
PD catheter kinking





Catheter tip migration

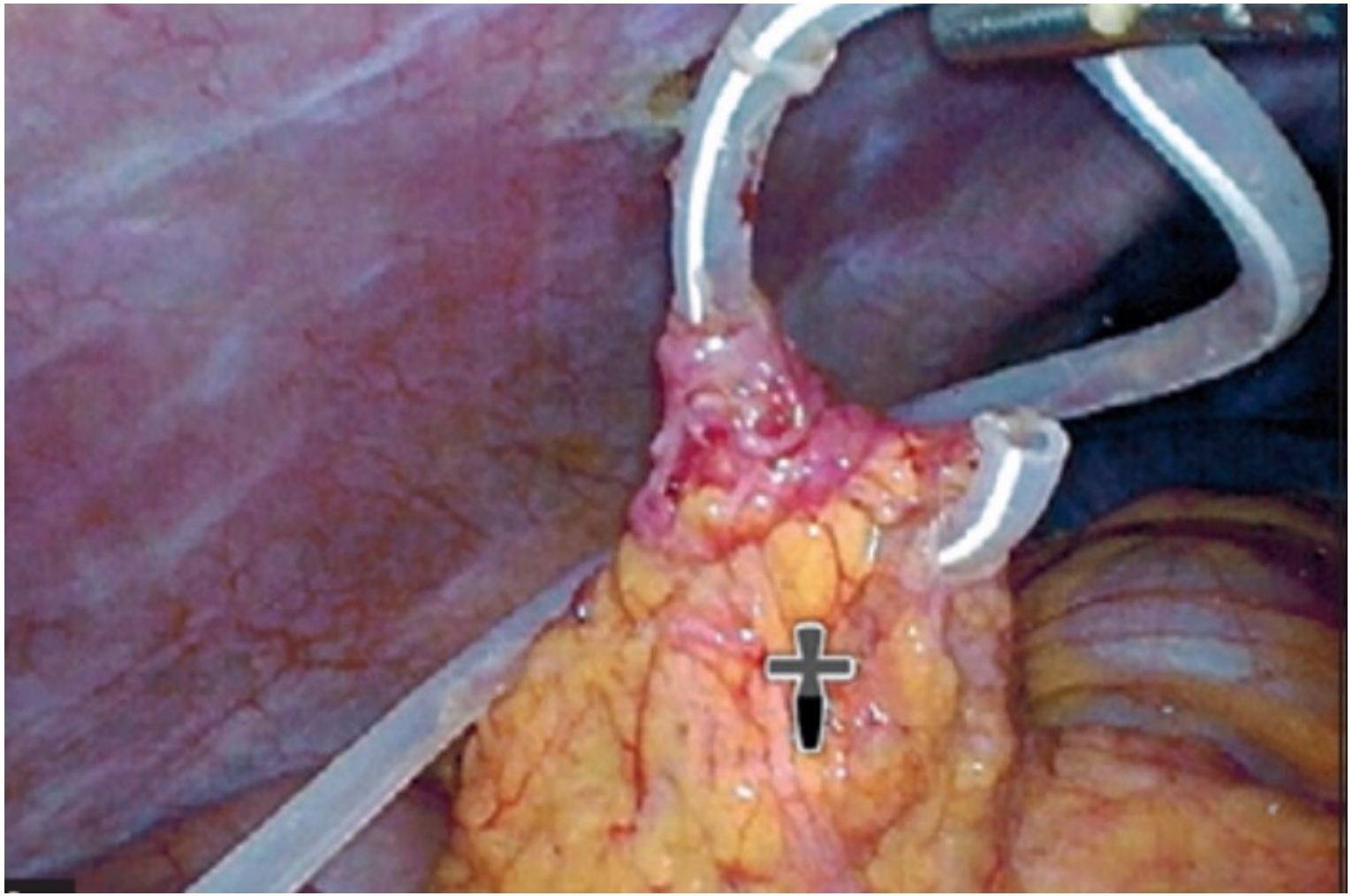




Adult RCT - catheter fixation to the lower abdominal wall combined with a straight upward tunnel configuration and low implant position

Zhang Q, et al. Nephrology (Carlton) 2018; 23:247-252.

Omental trapping



Omentectomy – Controversial data - physician's discretion in the current practice

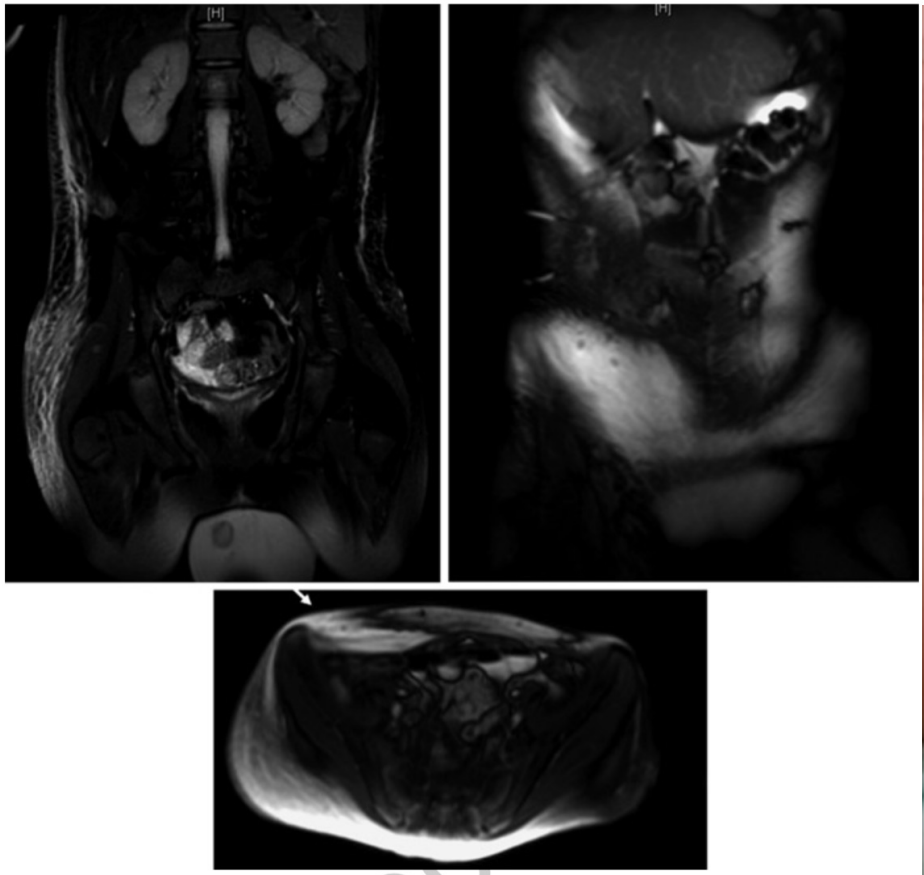
- 2-3 times reduced catheter replacement rate in patients undergoing an omentectomy (7-15% vs 23-27%)
    - LaPlant MB, (2018). Pediatr Surg Int 34:1239-1244.
    - Phan J, J Pediatr Surg 2013 48:197-202.
    - Ladd AP, et al. 2011Am J Surg 201:401-404
- Omentectomy did not change early or late mechanical complications and the re-operation rate
    - Carpenter JL, at al. J Pediatr Surg 2016; 51:730-733
    - Radtke J, et al. J Pediatr Surg 2018; 53:640-643.

Pericatheter Leakage 3-41%

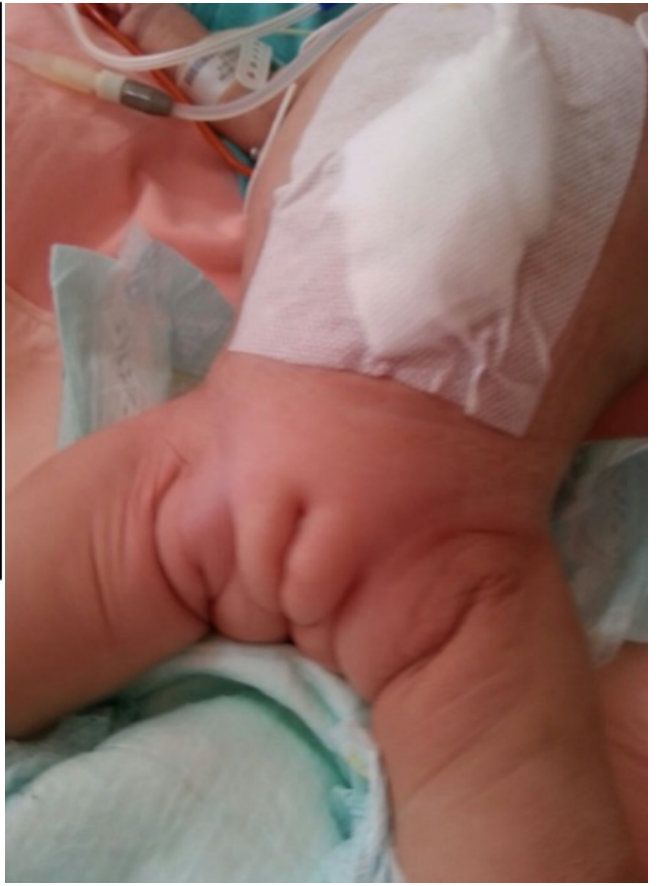
Neonates, infants
Weak abdominal wall
Low subcutaneous fat
Immediate use?
Omentectomy?

Low initial dialysis volume: 300 ml/m^2
Fibrin glue

Internal leakage

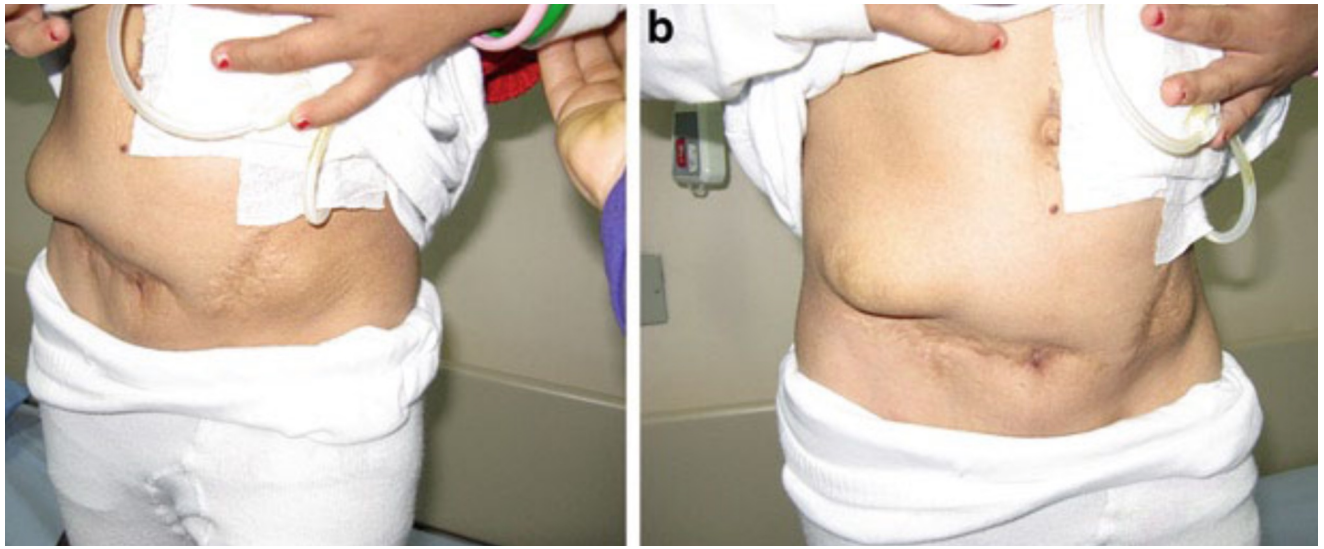


Courtesy of Dr. Franz Schaefer



Bakkaloglu SA, Pediatric Dialysis 2021, courtesy of Dr. Yavaşcan

Hernias – up to 30%



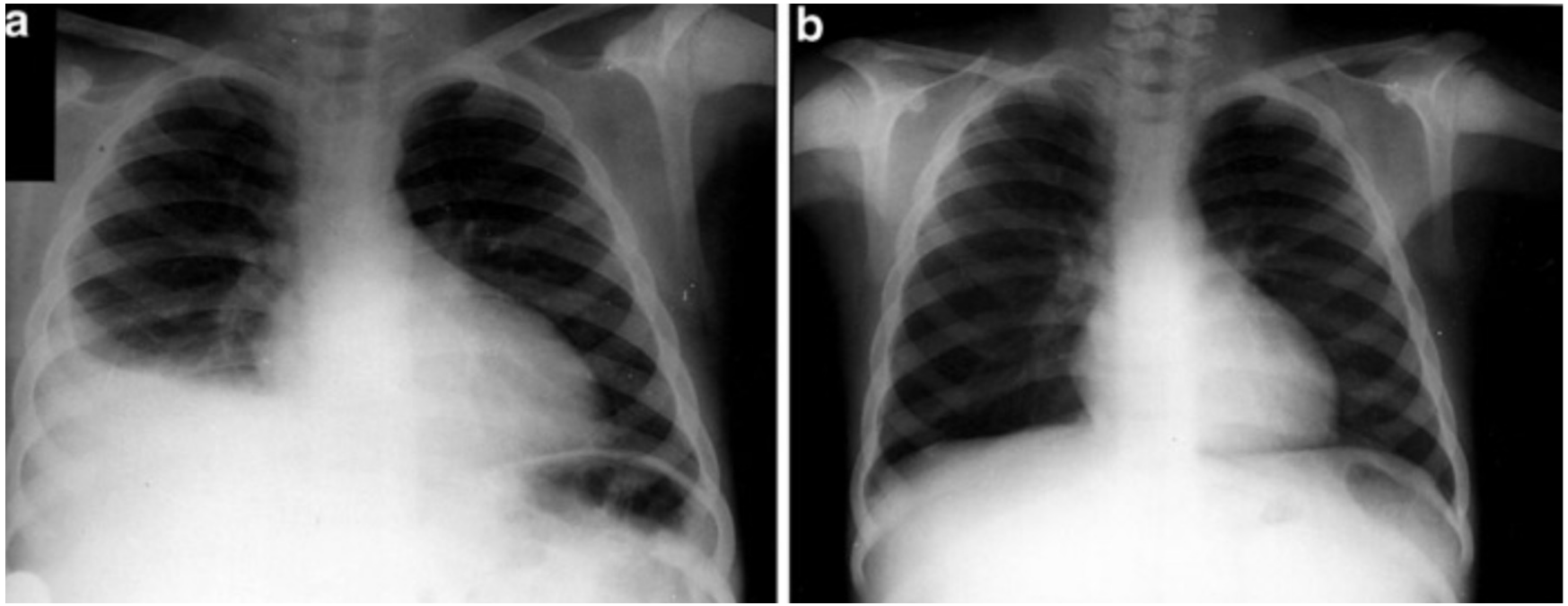
Bakkaloglu SA, Pediatric Dialysis 2012

Bakkaloglu SA, Pediatric Dialysis 2021, courtesy of Dr. Yavaşcan

IPP
Weak sites in the abdominal wall
Small age

8-57%, newborn and small infants → Prophylactic closure of Processus vaginalis at PD cath insertion

Hydrothorax - 1.6% - 10%



Lymphatic drainage problem
Congenital diaphragmatic defect
Negative intrathoracic pressure
Positive intraabdominal pressure
IPP

Cessation of PD
Small volume PD
Thoracoscopic pleurodesis – diaphragmatic repair
Open surgery for recurrent hydrothorax cases

Bakkaloglu SA, Pediatric Dialysis 2012

EPS Encapsulated peritoneal sclerosis

Courtesy of Dr. Ekim

Courtesy of Dr. Bakkaloglu

Long dialysis
>5 yrs of PD – incidence of EPS 6.6%
>10 yrs of PD – incidence of EPS 22%

Terminology of peritonitis

Recurrent	An episode that occurs within 4 weeks of completion of therapy of a prior episode but with a different organism
Relapsing	An episode that occurs within 4 weeks of completion of therapy of a prior episode with the same organism or 1 sterile episode
Repeat	An episode that occurs more than 4 weeks after completion of therapy of a prior episode with the same organism
Refractory	Failure of the effluent to clear after 5 days of appropriate antibiotics
Catheter-related peritonitis	Peritonitis in conjunction with an exit-site or tunnel infection with the same organism or 1 site sterile