

Access Care and Complications Management Update

2017

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Care of the Adult Patient on Peritoneal Dialysis

John H. Crabtree, MD

Beth Piraino, MD

Maggie Gellens, MD

Steven Guest, MD

Catherine A. Firanek, BSN, MBA

Ann Mancini, RN, MSN, FNP

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Based in part on recommendations from the International Society
for Peritoneal Dialysis

Author Affiliations:

John H. Crabtree, MD
Visiting Clinical Faculty
Division of Nephrology and Hypertension
Harbor-University of California Los Angeles
Medical Center
Torrance, California

Beth Piraino, MD
Professor of Medicine
Associate Dean of Admissions
University of Pittsburgh School of Medicine

Maggie Gellens, MD
Medical Director
US Medical Affairs
Baxter Healthcare Corporation

Steven Guest, MD
Director Medical Consulting Services
US Marketing
Baxter Healthcare Corporation

Catherine A. Firanek, BSN, MBA
Director Global Medical Affairs
Renal Division
Baxter Healthcare Corporation

Ann Mancini, RN, MSN, FNP
Medical Science Liaison
US Medical Affairs
Baxter Healthcare Corporation

Optimal long-term management of the peritoneal dialysis (PD) patient hinges on achievement of best demonstrated practices and prevention of complications associated with peritoneal dialysis. Published recommendations enhance our understanding of how to achieve these goals and encourage focus on prevention, leading to improved management of our patients overall.

Access management is an essential element for long-term patient success with peritoneal dialysis. Proper placement of the catheter and postoperative care of the healing exit-site are key to establishing a successful permanent peritoneal access. A decrease in access-associated complications, particularly peritonitis, can be achieved if definitive focus is placed on proper catheter placement, use of advanced disconnect systems, exit-site prophylaxis, and, most importantly, the patient's adherence to aseptic technique during the exchange procedure and to the protocol for exit-site care. Early intervention and treatment of peritoneal catheter related complications, if they do occur, are essential to maintaining the peritoneal access for prolonged successful peritoneal dialysis.

While there have been improvements made in the catheter area in both hemodialysis (HD) and peritoneal dialysis, access issues continue to be significant causes of morbidity in the dialysis patient. PD catheter-related infections and complications continue to be major reasons why patients discontinue PD.

Access Care and Complications Management was developed based on a review of the current medical literature, the recommendations of the International Society for Peritoneal Dialysis (ISPD) ad hoc advisory committee on PD-related infections, and the authors' clinical experience. Sections include operative planning and processes, chronic catheter care, and infectious and noninfectious complications, with suggested references and additional information in the appendix. By its nature, this guide cannot be considered to be exhaustive, and users are encouraged to pursue specific issues that may not be covered herein. **Therefore, this guide should not replace the independent clinical judgment of the healthcare provider.**

This guide was developed as an aid to improve PD catheter management in the adult patient. It is our hope that these guidelines will assist you in improving patient care by optimizing PD catheter outcomes.

Please note: Certain products discussed in this guide are not available in all geographic locations.

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Use of the Guide

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Use of the Guide

The format of the guide has been designed to provide the user a consistent approach for optimal peritoneal catheter and complications management. Each section is intended to proactively address the key activities required to achieve desired clinical outcomes, to promote early recognition of complications with appropriate clinical interventions, and to collect clinical data necessary for outcomes assessment.

The information published in this guide is for general and educational purposes only and should not be construed as medical advice or otherwise substitute for the independent clinical judgment of healthcare providers.

Use of the Guide

Clinical Process of Care

Identifies the clinical processes of care that contribute to the overall outcome of improved catheter and complications management.

KEY ASSESSMENTS

Identifies major clinical findings that must be incorporated into development of the plan of care. The intent is to supplement good clinical judgment and facilitate coordination of team activities.

KEY ACTIVITIES

Identifies major activities of members of the renal team who organize and support achievement of the desired clinical outcome.

PATIENT EDUCATION

Utilizes assessment and diagnostic findings to create an individualized patient/caregiver education program, maximize self-care skills, and promote adaptation to the therapy.

OUTCOMES EVALUATION

Identifies data required for tracking, trending and comparative benchmarking through a clinical monitoring system and for analysis by the continuous quality improvement (CQI) team to improve clinical outcomes.

section

1

Catheter Insertion and Care

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Preoperative Management

Catheters can be placed surgically or percutaneously by Interventionalists. Optimal timing for peritoneal catheter insertion should take place at least 2 weeks prior to use of the catheter. This is to ensure good tissue ingrowth and fixation of the deep and superficial cuffs and healing of the exit-site.¹ While optimal time to first use is 2 weeks, many PD catheters can be used more urgently if required to initiate dialysis (urgent-start PD).

KEY ASSESSMENTS

- Determine factors that may impair initial wound healing and exit-site management
 - Clinical status (chronic cough, steroids use, edema)
 - Nutritional status (malnutrition impairs healing)
 - Obesity-pannus location²
 - Presence of colostomy, gastrostomy, or urostomy
 - Use of adult diapers
- Evaluate for:
 - Abdominal wall for rash and evidence of infection
 - Pre-existing abdominal scars
 - Chronic intertrigo under breasts and abdominal skin folds
 - Abdominal wall hernias that require repair³
 - *S. Aureus* nasal carriage. If positive, treat with intranasal mupirocin⁴

KEY ACTIVITIES

- Set up appropriate communication plan with surgeon for catheter placement and patient follow-up (see Appendix)
- Confirm catheter placement date
- Determine exit-site location that optimizes longevity and patient satisfaction
 - Patient preference should be considered in determining exit-site placement unless there is a strong clinical indication that precludes choice
 - Locate exit-site to maximize self-care skills (vision, handedness, strength, and motor skills).^{2,5} Patient should be able to look down and easily visualize the proposed exit-site
 - Evaluate patient while dressed and in the sitting position to determine belt-line location and other anatomical features that will influence selection of catheter type, insertion site, and exit-site location
 - Avoid scars, belt line, skin creases, apices of floppy skin folds, moist areas due to perspiration, pressure points from clothing or areas that cannot be sufficiently visualized during exit-site care²
 - Determine whether lower abdominal, midabdominal, high abdominal, or presternal location is most appropriate for individual patient
 - Mark exit-site location with indelible ink using stencils or actual catheter or record measurements of exit-site position in relation to anatomical landmarks that will permit subsequent indication of exit-site location (see Appendix)
- Choose appropriate catheter configuration and operative methodology
 - Despite innovative attempts to design peritoneal catheters to overcome problems with flow function, none of these devices have been shown to outperform the standard Tenckhoff-style catheters with or without a preformed intercuff bend or a straight- or coiled-tip configuration^{3,2}

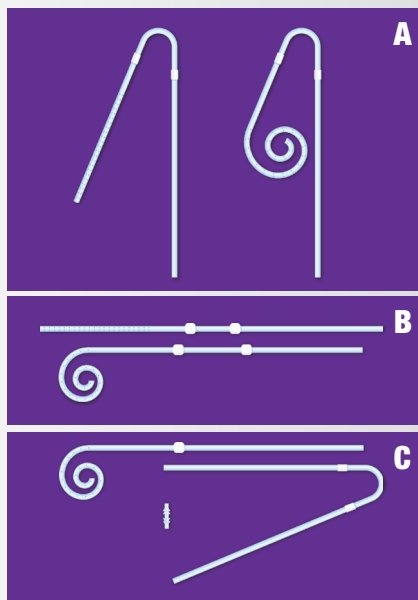


Figure 1. Shown are commonly used peritoneal catheters. (A) Tenckhoff catheters with preformed intercuff arc bend, 2 cuffs, and straight or coiled tips. (B) Tenckhoff catheters with straight intercuff segment, 2 cuffs, and straight or coiled tips. (C) Extended catheter with one-cuff, coiled-tip abdominal catheter, two-cuff extension catheter with preformed intercuff arc bend, and titanium double-barbed connector.

Preoperative Management

Patients with belt lines BELOW umbilicus



FIG. 2
Patients with belt lines below the umbilicus may require a Tenckhoff-style catheter that produces a laterally directed exit-site above the belt.

Patients with belt lines ABOVE umbilicus



FIG. 3
Patients with belt lines above the level of the umbilicus may require a catheter that is bent or manufactured with a preformed bend that results in a downwardly directed exit-site.

Illustrations courtesy of John Crabtree, MD

Indications for Presternal/Upper Abdominal Peritoneal Dialysis Catheter³

- Morbid obesity
- Multiple loose skin folds, scars, or other abdominal wall deformities
- Chronic abdominal wall intertrigo
- Abdominal stomas (colostomy, ileostomy, urostomy)
- Urinary or fecal incontinence
- Desire to be able to take deep tub bath^{2,6}
- Patient preference

Contraindications for Presternal/Upper Abdominal Peritoneal Dialysis Catheter

- Body image issues
- Breast implants (presternal)
- Requires surgical expertise

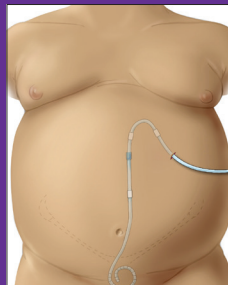


FIG. 4
An extended catheter for upper abdominal exit-site may be useful for patients with obesity or floppy skin folds or per patient preference.³

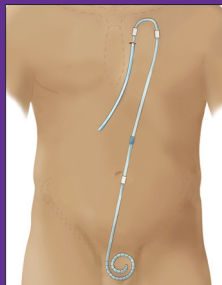


FIG. 5
An extended catheter with an upper chest exit-site can be utilized in patients with morbid obesity, abdominal stomas, or urinary-fecal incontinence or per patient preference.³

Illustrations courtesy of John Crabtree, MD

Preoperative Management

- Choice of catheter type may be impacted by belt-line location and body habitus²
 - Patients with belt lines below the umbilicus are often best suited for a catheter with a straight intercuff segment that is bent in a gentle arc to produce a laterally directed exit-site above the belt (Figure 2)²
 - Patients with belt lines above the level of the umbilicus are often best suited for a catheter with a preformed intercuff bend, a so-called swan neck design, that results in a downwardly directed exit-site below the belt (Figure 3)²
- Patients with obesity, especially with large rotund abdominal contours, or urinary-fecal incontinence may be best suited for an extended catheter to provide an upper abdominal exit-site (Figure 4)²
- Patients with morbid obesity, floppy skin folds, abdominal stomas, urinary-fecal incontinence, or those desiring to be able to take a deep tub bath may be suitable candidates for an extended catheter to produce a presternal exit-site (Figure 5)³
- Patients for whom dialysis initiation is not anticipated until at least 3 to 5 weeks after catheter implantation may benefit from having the catheter embedded (Moncrief-Popovich technique) (Figures 6A, 6B)⁷
- Catheter embedding procedure can be performed with any catheter type, i.e., conventional Tenckhoff abdominal catheters or two-piece extended catheters for upper abdominal or presternal exit-sites²

Advantages of Embedded Peritoneal Dialysis Catheter²

- Catheter heals in environment without exposure to contamination from exit-site
- Greater patient acceptance for earlier catheter implantation:
 - No catheter maintenance until dialysis starts
 - Avoids urgent temporary hemodialysis
- Start full-dose peritoneal dialysis without break-in period after exteriorization

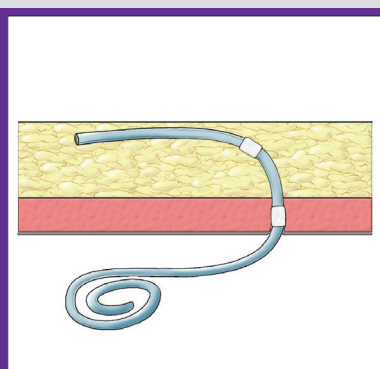


FIG. 6A

The external limb of catheter is buried under the skin, permitting healing and tissue ingrowth of the cuffs in a sterile environment.

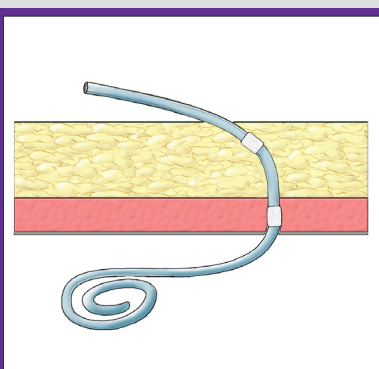


FIG. 6B

External limb of catheter is exteriorized when time to initiate dialysis.

Preoperative Management

PATIENT EDUCATION

Ensure PD education program is underway, including the following topics:

- Home dialysis concept
- Basics of PD therapy
- Permanency of catheter until transplantation
- Self-care concept
- Postoperative catheter care
 - Dressing changes following implantation should be restricted to experienced PD staff or trained patients
 - Provide postoperative care instructions and, if applicable, supplies including: soap/alcohol-based hand disinfectants, masks, absorbent dressing (e.g., gauze), tape, and exit-site cleansing agent/skin disinfectant

Review written operative instructions with patient/caregiver:

Preoperative:

- Review catheter placement procedure
- Fast after midnight or at least 8 hours prior to catheter insertion (essential medications are permitted with a sip of water)
- Empty bladder^{1, 3, 5}
- Bowel preparation to evacuate the lower colon in case of previous history of constipation (e.g., polyethylene glycol solution, enema, or a stimulant suppository administered beginning a day or two before the procedure depending on the severity of symptoms)^{1, 3, 5}
 - Avoid using sodium phosphate bowel preps⁸
- Shower or bathe with disinfectant soap on the day of surgery^{1, 3, 5}

Postoperative:

- Keep sterile dressing clean, dry, securely taped for one week unless there is excess drainage or bleeding¹
- Report bleeding, pain, or tenderness immediately
- Report severe cough
- Avoid high intra-abdominal pressure until healed (2 to 6 weeks):
 - Heavy lifting
 - Straining and constipation
 - Pulling with upper extremities during stair climbing
 - No showers until completely healed up to 2 weeks⁵ (2 days in case of embedded catheters)⁷

OUTCOMES EVALUATION

Collect patient information to include:

- Patient demographics
- ESRD diagnosis
- Comorbid conditions
- Date of referral

Enter data into catheter management database

Perioperative and Intraoperative Management

Peritoneal catheter implantation must be performed by a competent and experienced surgeon or interventional radiologist or nephrologist. Optimal long-term peritoneal catheter function and exit-site healing are directly related to the skills and competence of the catheter insertion team. Proper catheter insertion technique is one of the most important aspects in preventing catheter exit-site and/or tunnel infections. Attention to detail and commitment to excellence should be foremost in goals for success. Peritoneal catheter insertion procedures should meet the standards of any surgical procedure and inclusive of known best demonstrated practice, whether performed by a surgeon in the operating room, an interventional radiologist in a radiology suite, or an interventional nephrologist at the bedside.¹

KEY ASSESSMENTS

- Verify completion of preoperative activities:
 - Fasting state maintained
 - Shower on day of surgery with chlorhexidine soap⁵
 - Bladder emptied or Foley catheter as needed^{1, 3}
 - Bowel preparation complete^{1, 3}
- Verify exit-site marked appropriately⁵

KEY ACTIVITIES

Prepare patient:

- Administer antistaphylococcal antibiotic preoperatively^{5, 9}
 - First-generation cephalosporin 1000 mg intravenously, 1 to 3 hours preoperatively

OR

- Vancomycin 1000 mg intravenously, administered approximately 12 hours preoperatively^{10*}
- A prospective randomized trial determined that vancomycin was superior to cephalosporin or no treatment in reducing post-operative peritonitis^{10*}
- If vancomycin is used, weigh potential benefits versus risk of resistant organisms**
- Perform surgical skin prep (use electric clipper to avoid skin nicks)³

Prepare catheter:

- Eliminate air from catheter cuffs prior to implantation by soaking and gently squeezing cuffs in saline solution⁵

*The half-life of vancomycin and cefazolin are different, possibly influencing the results of this study

**The epidemiology and resistance patterns contributing to peritonitis should be considered in determining the appropriate preoperative antibiotics

Perioperative and Intraoperative Management

Insert catheter:

Catheter implantation approaches include laparoscopic, laparoscopic-assisted, open dissection, and percutaneous needle-guidewire with or without image guidance. The following general guidelines should be adhered to irrespective of implantation technique chosen:

- Preoperative determination of most appropriate catheter type, insertion site, and exit-site location
- Use of double cuff catheter preferred¹¹
- Paramedian insertion through body of rectus muscle and sheath to provide optimal catheter immobilization and minimize risk of pericatheter leak and hernia (Figure 7)⁵

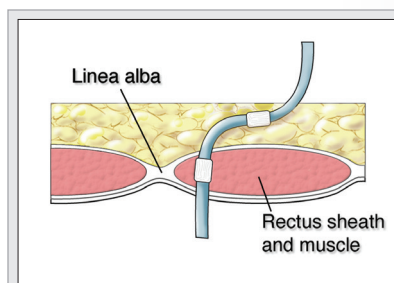


FIG. 7

Peritoneal dialysis catheter implanted through paramedian approach with deep cuff resting within the muscle.

- Position deep cuff within rectus muscle sheath⁵
- Implanting deep cuff superficial to rectus fascia can lead to formation of hernia or pseudohernia and late pericatheter leak (Figure 8)⁵

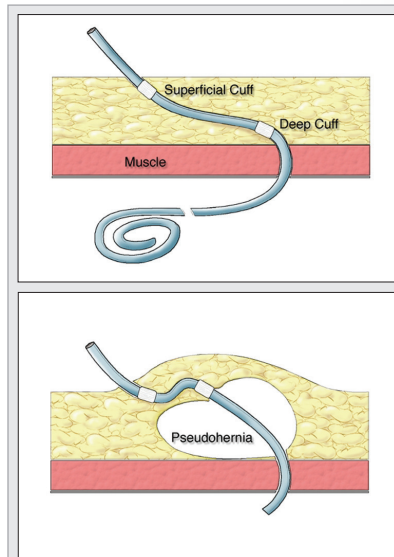


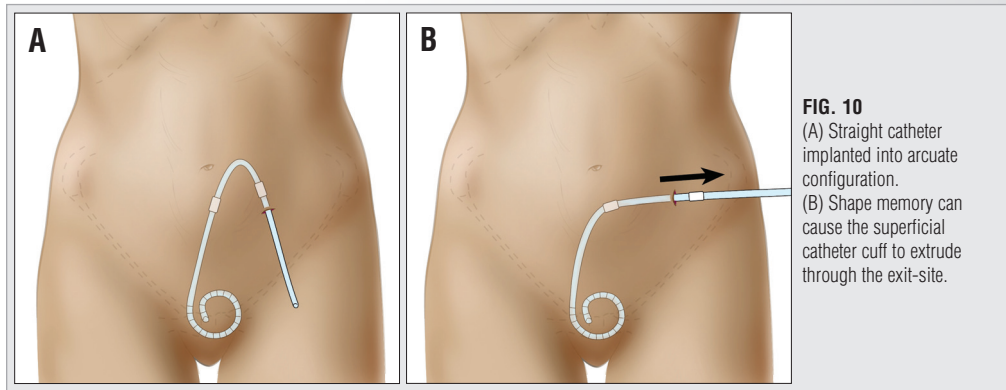
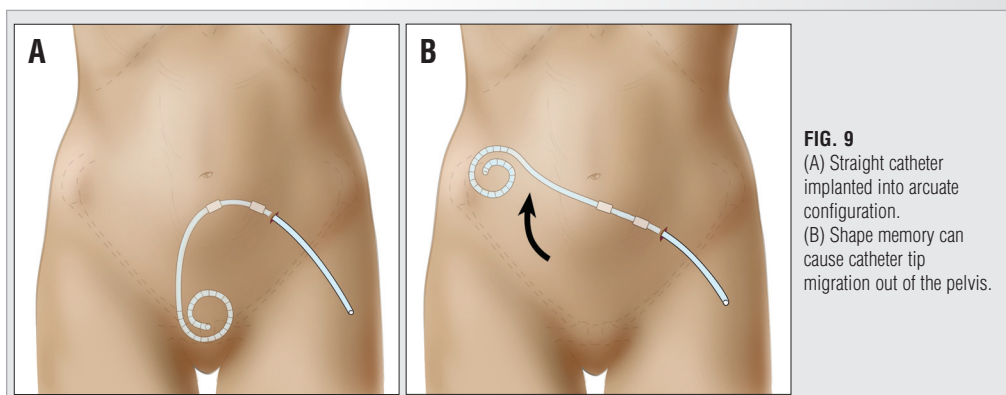
FIG. 8

(Top) Deep catheter cuff implanted external to the fascia. The mesothelium from the peritoneal surface reflects along the surface of the catheter to reach the deep cuff.

(Bottom) The extension of the peritoneal lining above the muscle layer creates the potential for a pseudohernia and pericatheter leak. If the abdominal wall is weak, the track may dilate and develop a true hernia.

Perioperative and Intraoperative Management

- Catheter tip should have pelvic location⁵
- Place purse-string absorbable suture at level of peritoneum during open dissection or anterior rectus fascia with laparoscopic or percutaneous insertion to reduce risk of pericatheter leak⁵
- Catheters with straight intercuff segment should not be bent excessively in subcutaneous tissues to avoid creating shape memory resiliency forces that can lead to catheter tip migration and superficial cuff extrusion (Figures 9 and 10)³
- Subcutaneous tunneling instruments should not exceed diameter of dialysis catheter and should be capable of being advanced in direction from insertion site toward exit-site
- Create the smallest skin hole possible to provide for catheter exit-site⁵
- Position subcutaneous cuff 2 to 4 cm from exit-site⁵



Illustrations courtesy of John Crabtree, MD

- Exit-site should face downward or lateral⁵
- Immobilize catheter with medical adhesive tincture (if available) and sterile adhesive strips²
- Do not utilize catheter anchoring sutures at the exit-site due to risk of infection⁵
- Perform adjunctive procedures to catheter implantation such as hernia repair, omentopexy, omentectomy, and adhesiolysis as needed

Perioperative and Intraoperative Management

Verify function:

- Catheter patency and flow must be tested during surgical procedure prior to final closure. With the patient in reverse Trendelenburg position, a trial irrigation is performed by infusing a standard 1-liter bag of normal saline with heparin (1000 U per liter) and observe for unimpeded inflow and drainage by gravity. A residual volume of 250 to 300 mL is left in the abdomen to reduce the likelihood of intraperitoneal structures being siphoned up to catheter tip and side holes toward the end of the drainage phase
- Catheter position should be revised until satisfactory flow function is achieved before procedure end
- With non-laparoscopic implantation methods, it is advisable to check for catheter patency and flow prior to exteriorizing the catheter through the exit-site. This will prevent unnecessary tunnel track and exit-site trauma in the event that catheter repositioning is required.

Final catheter preparation:

- Insert catheter adapter
- Attach catheter cap or transfer set with cap (as per individual center policy)
- Make sure transfer set is in closed position
- Apply sterile gauze or other nonocclusive absorbent dressing and tape securely^{1, 12}
- Tape catheter and transfer set securely to abdomen in several places
- Occlusive or semi-occlusive dressings may be used¹²

PATIENT EDUCATION

- Review postoperative instructions prior to patient discharge
- Provide written instructions regarding follow-up care (see Appendix)
- Review postoperative medications
- Review postoperative pain management
- Schedule return appointment for postoperative evaluation and ideally for weekly dressing changes by experienced staff

OUTCOMES EVALUATION

Review operative report for baseline catheter data:

- Date, surgeon, inpatient/outpatient placement, surgical approach, special procedures
- Catheter type, catheter material, position of cuffs, direction of exit-site
- Catheter function

Enter data into catheter management database

Postoperative Management

Optimal postoperative care promotes healing of the exit-site wound and the catheter track. Postoperative care includes immobilization of the catheter to prevent trauma to the exit-site and cuffs, minimizing exposure to bacteria and preventing colonization.¹³ If possible, implantation should be timed to allow 2 weeks for healing prior to initiation of dialysis. If dialysis is required early, small volume exchanges in the supine position may be performed with frequent checks for leakage. Postoperative assessment and dressing changes should be performed weekly by experienced staff only using aseptic technique with mask and gloves until healed.¹

KEY ASSESSMENTS

- Assess exit-site and wound healing for:
 - Absence of bleeding, drainage, or leakage
 - Absence of pain or tenderness on palpation

KEY ACTIVITIES

- Inspect and change dressing weekly or more frequently in the presence of:
 - Delayed healing
 - Infection¹
 - Gross contamination
 - Wetness
- Maintain clean, dry, intact dressings¹
- Utilize aseptic technique using mask and gloves¹
- Exit-site care:
 - Minimize manipulation of catheter
 - Use aseptic technique, including masking and wearing sterile gloves for postoperative dressing changes until healed¹³
 - Inspect and classify exit-site^{1, 14}
 - Palpate tunnel
 - Clean with nonirritating solution (i.e., nonionic surfactant, normal saline, or chlorhexidine)^{1, 11}
 - Protect sinus track and wound from povidone iodine and hydrogen peroxide^{1, 14}
 - Tape dressing securely¹
 - Immobilize catheter¹
- Perform catheter irrigation with 500–1000ml saline or dialysate within 24 hours following catheter insertion to wash out blood and fibrin that can plug the catheter and/or form obstructing adhesions.
- If the catheter is not used for a time, it is advisable to repeat irrigation periodically, such as during weekly dressing changes, to assure patency and function by the time the patient is ready to start dialysis training. Heparin, 1000 units/L may be added to irrigant to help prevent blood clots and fibrin plugs.
- Catheters that are exteriorized secondarily (Moncrief technique) can be used immediately for full-volume peritoneal dialysis.⁷ Exit-site management for secondarily exteriorized catheters is the same as described for primary exteriorization.

Postoperative Management

PATIENT EDUCATION

- Review postoperative instructions with patient:
 - Maintain clean, dry, securely taped sterile dressing
 - Protect site from gross contamination and wetness
 - Immobilize catheter
 - Practice good hygiene
 - Take no shower or bath until healed^{11, 13}
 - Avoid heavy lifting, stair climbing, straining, and constipation until catheter is healed (2 to 6 weeks)
 - Notify PD unit in case of blood or other drainage, pain or tenderness, trauma to abdomen
- Restrict dressing changes following implantation to experienced PD staff or trained patients (if patient lives far from center)¹³
- Educate patients who perform postoperative dressing changes to:
 - Recognize early signs of infection such as redness, tenderness, and discharge
 - Use aseptic technique with face mask and gloves
 - Inspect exit-site and palpate tunnel
 - Maintain stability of catheter during inspection
 - Cleanse with nonirritating solutions when instructed by nurse

OUTCOMES EVALUATION

Collect data to include:

- Exit-site classification

Enter data into catheter management database

Chronic Care of Peritoneal Dialysis Catheter

Optimal long-term peritoneal catheter management focuses on maintaining a healthy exit site and catheter track. Catheter survival of greater than 80% at one year is desired.^{1,3} The primary preventative steps are ongoing assessment of the exit-site, institution of antibiotic prophylaxis, early identification and treatment of exit-site problems, prevention of contamination, and immobilization of the catheter to protect from trauma.

KEY ASSESSMENTS

- Inspect exit-site using magnifying glass as needed
- Evaluate exit-site and sinus track
- Examine exit-site appearance by checking for:¹⁴
 - absence of drainage, erythema, crust, scab, granulation tissue, swelling, and pain or tenderness on palpation
- Palpate tunnel
- Compare exit-site appearance on each clinic visit
- Verify function and assess integrity of peritoneal catheter by querying patients on CAPD for fill and drain duration, or by reviewingycler logs for fill and drain profiles for APD patients
- Review chronic catheter care with patient
- Ensure compliance with topical antibiotic prophylaxis

KEY ACTIVITIES

- Document exit-site and tunnel appearance at each clinic visit
- Obtain exit-site culture if drainage or wetness noted
- Perform exit-site care as required
- Review and reinforce exit-site and catheter care plan

ANTIBIOTIC PROPHYLAXIS

ISPD recommends one of the following:⁴

- Gentamicin 0.1% cream daily at exit-site effective in reducing both gram-positive and gram-negative infections
- Mupirocin cream or ointment daily at exit-site effective in reduction of gram-positive infections
- Apply to skin around catheter site only, not catheter¹⁵

Chronic Care of Peritoneal Dialysis Catheter

PATIENT EDUCATION

Daily routine exit-site care:

- Wash and dry hands thoroughly^{1, 13}
- Inspect catheter, exit-site, and tunnel before catheter care¹
- Showers recommended; avoid immersion in tub
- Cleanse exit-site every day, or a minimum of two times per week⁴
- Cleanse exit-site with liquid antibacterial soap or antiseptic (i.e., povidone iodine or chlorhexidine)¹¹
- Cleansing agent should be nonirritating, nontoxic, antibacterial, and in liquid form^{1, 13}
- Do not transfer cleansing agent between containers to avoid cross-contamination^{1, 13}
- Soften crusts and scabs with saline or soap and water. Never forcibly remove crusts and scabs^{1, 13}
- Apply antibiotic cream or ointment for prophylaxis using a cotton swab. Do not apply directly from tube
- Avoid mupirocin ointment with polyurethane catheters¹¹
- May immobilize catheter with tape or immobilization device at all times
- Apply dressing to protect from contamination¹⁷
- Povidone iodine can be damaging to the peritoneal catheter over time
- Healed site may be left uncovered but should be kept dry¹⁷
- In case of prophylactic antibiotics, a nonocclusive dressing may be suitable
- Perform exit-site care if exit-site becomes wet or grossly contaminated¹³
- Report trauma of exit-site or catheter
- Maintain regular soft bowel movements¹¹

CARE FOR PATIENTS WHO SWIM¹⁸

- Exposure to water with high concentration of bacteria may lead to exit-site infection and potential loss of the peritoneal catheter
- Swimming may be allowed for patients with fully healed exit-site
- Avoid swimming in the presence of exit-site infection
- Apply waterproof/occlusive dressing over exit-site area
- Avoid submersion of unprotected exit-site in water, particularly in a public pool, hot tub, or Jacuzzi
- Swimming in a private chlorinated pool or salt water may have less risk for contamination
- Perform exit-site care immediately following submersion in water
- Assure the exit-site is well dried after swimming

OUTCOMES EVALUATION

Collect data to include:

- Exit-site classification/assessment
- Culture date, result, and treatment
- Topical antibiotic regimen
- Evaluation of catheter outcomes
 - Peritonitis rate
 - Exit-site/tunnel infection rate
 - Catheter survival

Enter data into catheter management database

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14. Twardowski ZJ, Prowant BF. Classification of normal and diseased exit sites. *Perit Dial Int* 1996;16:532–50.
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16. Piraino B, Bernardini J, Figueiredo A, et al. ISPD position statement on reducing the risks of peritoneal dialysis-related infections. *Perit Dial Int* 2011;31:614–30.
17. Mushahar L, Mei LM, Yusuf S, et al. Exit-site dressing and infection in peritoneal dialysis: a randomized controlled pilot trial. *Perit Dial Int* 2016;36:135–9.
18. Twardowski ZJ, Nichols WK. Peritoneal dialysis access and exit-site care including surgical aspects. In: Gokal R, Khanna R, Krediet R, Nolph K. *Textbook of Peritoneal Dialysis*, 2nd ed. Dordrecht, Netherlands: Kluwer Academic Publishers; 2000:307–62.

section

2

Noninfectious Complications

Baxter

Noninfectious Complications

Pericatheter and Subcutaneous Leaks

Pericatheter and subcutaneous leaks are often related to poor catheter implantation technique, anatomical abnormalities, early use of the recently placed catheter or trauma.¹ Leakage occurring in the first 30 days following catheter implantation is usually external in nature and is evident at the catheter exit-site or surgical incision. Subcutaneous leaks may resolve with a prolonged rest period or dry day. Subcutaneous leakage involving the genital region or abdominal wall usually indicates a larger leak requiring exploration of the incision site or evaluation for an anatomical defect. Attention to surgical recommendations on insertion location (paramedian approach) and positioning of internal cuff reduce the risk of leakage.¹

Leaks confined to the genital area can occur thru a patent processus vaginalis, an embryological structure that allows for the developing genitals to exit the abdominal cavity into their mature anatomic location. In many individuals this processus vaginalis structure does not fuse normally after the genitals exit and allows for a patent communication between the abdominal cavity and genital anatomy.² These patients may present with massive scrotal or labial edema during initiation of PD.

Leaks are detected clinically by visualizing clear dialysate at the exit-site, by examination of the subcutaneous tissue that would present with a feeling of induration and fullness, or by obvious genital edema. Leaks at the exit-site can be confirmed with glucose testing of the visible fluid. Subcutaneous leaks and genital leaks can be confirmed by either CT peritoneography, scintigraphy, or MRI.^{3, 4, 5}

KEY ASSESSMENTS

Patients at risk:

- Patients with poor tissue healing (diabetics, elderly, malnourished, and those taking corticosteroids)
- Patients with increased intra-abdominal pressure¹

Findings that require evaluation for leaks:¹

- External fluid at wound or exit-site
- Reduced exchange outflow volume
- Weight gain
- Abdominal swelling and edema/increased girth
- Scrotal, penile, or labial edema
- Peripheral edema
- Unilateral pleural effusion with or without volume overload (see Noninfectious Complications-Hydrothorax)

Noninfectious Complications

KEY ACTIVITIES

External leaks:

- Verify that clear fluid at incision or exit-site contains glucose, using glucose test strip
- Document condition of exit-site, subcutaneous cuff, tunnel, and/or wound
- Alter dressing change procedure to accommodate increased fluid drainage
- Reduce leak by use of dry days, supine low volume dialysate exchanges, or temporary suspension of PD
- Leaks increase the risk of peritonitis, and consideration should be given to prophylactic antibiotic administration

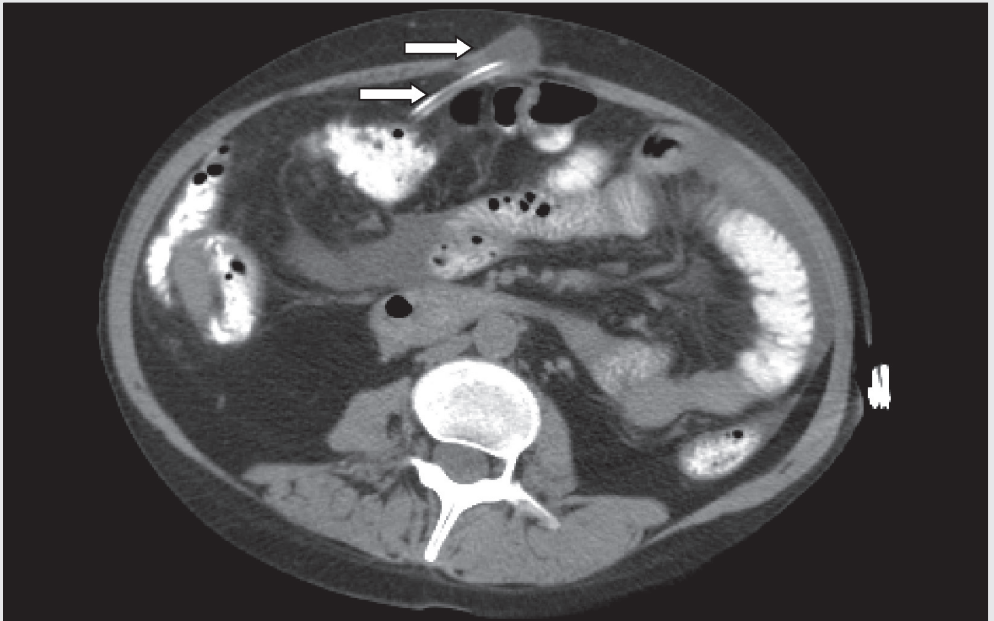
Subcutaneous leaks:

- Monitor girth
- Examine flank and back for subcutaneous fluid
- Examine for scrotal, penile, or labial swelling
- Order/review abdominal computerized tomography (CT) with intraperitoneal (IP) contrast, peritoneal scintigraphy, or magnetic resonance imaging (MRI) without gadolinium^{3, 4, 5} (see section Imaging Techniques)
- Increase clinic visits as needed for observation

IMAGING TECHNIQUES

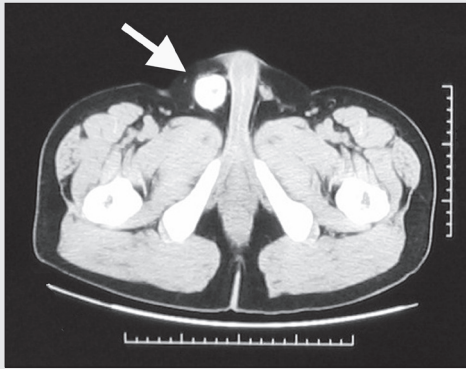
- CT peritoneography³ (see Appendix)
- Peritoneal scintigraphy⁴ (see Appendix)
- Peritoneal MRI with dialysate as “contrast medium”⁵ (see Appendix)

Pericatheter Leak



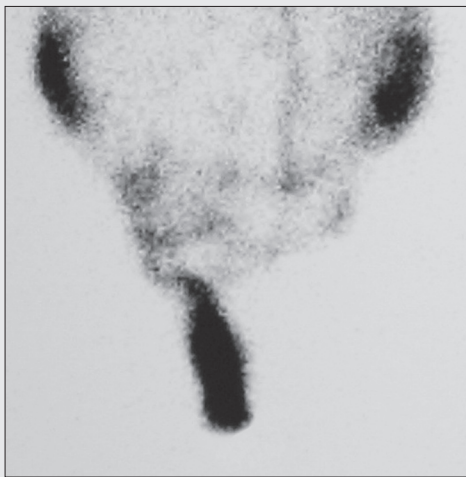
CT without IP contrast revealing a pericatheter leak in a patient with improper placement of the catheter. White arrows indicate catheter and leak area identified by different contrast to other subcutaneous tissue.

Noninfectious Complications



CT Peritoneography

CT peritoneography with IP contrast showing dye around the cord structures in the upper scrotum on the right side (arrow) at the level of the root of the penis.



Peritoneal Scintigraphy

Peritoneal scintigraphy postdrain image demonstrating right inguino-scrotal fluid collection.

Radiographs courtesy of John Crabtree, MD



MRI (Magnetic Resonance Imaging)

MRI showing anterior abdominal hernia. Dialysate brightly enhances in the subcutaneous tissue demonstrating a leak.

Radiograph courtesy of Brent Miller, MD

Noninfectious Complications

MANAGEMENT

Dialysis therapy:

- Initiate PD or APD in supine position, using low volume exchanges (500 to 1500 mL) until leak has resolved. Keep abdomen dry when not in supine position
- If required, use HD backup for 1 to 2 weeks

In new patients in whom dialysis is not urgently required:

- Delay use of PD for up to 3 weeks if necessary until leakage subsides¹
- Cautious reintroduction of PD after rest period with frequent monitoring for recurrence

Invasive steps:

- Persistent leak may require surgical repair¹
- Provide HD backup if needed during healing in patients with no residual renal function if low volume APD is not feasible or does not adequately control azotemia
- Recurrent pericatheter leaks may require catheter replacement¹

PATIENT EDUCATION

- Monitor for signs and symptoms of exit-site infection and peritonitis in presence of leaks
- Alter dressing change procedure and frequency to accommodate increased drainage
- Report physical examination changes indicating potential leak
- Alter dialysis regimen if required to minimize intra-abdominal pressure
- Reduce activities that increase intra-abdominal pressure such as lifting, coughing, or straining

OUTCOMES EVALUATION

Collect data to include:

- Type of catheter and insertion technique
- Condition of exit-site/surgical incision
- Condition of subcutaneous cuff and tunnel
- Type of leak
- Diagnostic testing and results
- Dialysis prescription alterations

Enter data into catheter management database

References:

1. LeBlanc M, Quimet D, Pichette V. Dialysate leaks in peritoneal dialysis. *Semin Dial* 2001;14:50–54.
2. Clarnette TD, Hutson JM. The development and closure of the processus vaginalis. *Hernia* 1999;3:97–102.
3. Litherland J, Lupton EW, Ackrill PA, et al. Computerized tomographic peritoneography: CT manifestations of in the investigation of leaks and abnormal collections in patients on CAPD. *Nephrol Dial Transplant* 1994;9:1449–52.
4. Juergensen PH, Rizvi H, Claride VJ, et al. Value of scintigraphy in chronic peritoneal dialysis patients. *Kidney Int* 1999;55:1111–19.
5. Prischl FC, Muhr T, Seiringer EM, et al. Magnetic resonance imaging of the peritoneal cavity among peritoneal dialysis patients, using the dialysate as "contrast medium". *J Am Soc Nephrol* 2002;13:197–203.

Noninfectious Complications

Peritoneal Catheter Obstruction

Inflow and outflow obstruction occurs more commonly as early complications but can also occur at any time, especially during or following episodes of peritonitis. Ascertaining the cause of obstruction will assist in determining the appropriate intervention.

KEY ASSESSMENTS

Inflow obstruction may be due to:

- Mechanical blockage such as clamps or kinks in transfer set or catheter including segment under the dressing
- Postimplantation blood clot or fibrin
- Fibrin, particularly with peritonitis

Outflow obstruction may be due to:

- Mechanical blockage of transfer set or catheter
- Postimplantation blood clot or fibrin
- Fibrin, particularly with peritonitis
- Constipation
- Extrinsic bladder compression due to urinary retention
- Catheter tip migration out of pelvis
- Catheter entrapment
 - Omental wrap
 - Epiploic appendices of colon
 - Fallopian tubes
 - Adhesions

KEY ACTIVITIES

Conservative noninvasive steps:^{1, 2}

- Eliminate kinks or remove clamps on transfer set and catheter. Examine portions hidden by clothing and dressings
- Change body position
- Dislodge blockage by forceful catheter flush (by experienced PD personnel)
 - Infuse dialysate or normal saline with a 50 mL syringe using moderate pressure (“push and pull” maneuver). Discontinue procedure if patient notes pain or cramping
- Correct constipation
- Obtain flat plate of abdomen to visualize catheter position; a lateral view may be necessary to identify a subcutaneous and intraperitoneal catheter kink

Noninfectious Complications

Invasive steps:

- Laparoscopy
- Open surgical repositioning of catheter or replacement
- Partial omentectomy or omentopexy³
- Adhesiolysis if indicated
- Fluoroscopically guided stiff wires or stylet manipulation⁴
- Fogarty catheter manipulation⁵

THROMBOLYTIC THERAPY FOR OBSTRUCTED CATHETER

- Instill recombinant tissue plasminogen activator (tPA)⁶

Administration of tPA

Prepare a solution of sterile water that has tPA 1 mg/mL. Instill up to 8 mLs (1–8 mg) after the filling of the abdomen with dialysis solution and allow to dwell for 1–2 hours. If the dialysate does not drain adequately, ensure that there is enough dialysate in the abdomen and re-instill the tPA at the same dose and allow to remain for an additional 90 minutes. Upon clearance of catheter, allow effluent to drain by gravity. Prior to initiating dialysis, the catheter may be flushed with sterile heparinized solution. Consider antibiotics (first-generation cephalosporin preferred) to dialysate in following exchange.

SHORT-TERM PREVENTION FOR RECURRENCE OF CATHETER OBSTRUCTION

In case of fibrin-related obstruction:

- Add heparin 500 U/L to each dialysate exchange⁷
-

PATIENT EDUCATION

- Tape catheter and transfer set to avoid kinking
- Position tubing to prevent kinking while asleep if using APD
- Prevent constipation with diet, exercise, and stool softeners
- Patient to report reduced drain volume

OUTCOMES EVALUATION

Collect data to include:

- Type of obstruction (inflow/outflow)
- Etiology
- Results of diagnostic testing
- Findings and responses to interventions

Enter data into catheter management database

References:

1. Gokal R, Alexander S, Ash, S, et al. Peritoneal catheters and exit-site practices toward optimal peritoneal access. *Perit Dial Int* 1998;18:11–33.
2. Dombros N, Dratwa M, Feriani M, et al. European best practices guidelines for peritoneal dialysis: 3 peritoneal access. *Nephrol Dial Transplant* 2005;[Suppl 9]:ix8–ix12.
3. Crabtree JH. Selected best demonstrated practice in peritoneal dialysis access. *Kidney Int* 2006;[Suppl 70]:S27–S37.
4. Miller M, McCormick B, Lavoie S, et al. Fluoroscopic manipulation of peritoneal dialysis catheters: outcomes and factors associated with successful manipulation. *Clin J Am Soc Nephrol* 2012;7:795–800.
5. Gadallah MF, Arora N, Arumugam R, Moles K. Role of Fogarty catheter manipulation in management of migrated, nonfunctional peritoneal dialysis catheters. *Am J Kidney Dis* 2000;35:301–5.
6. Zorzanello M, Fleming W, Prowant B. Use of tissue plasminogen activator in peritoneal dialysis catheters: a literature review and one center's experience. *Neph Nurs J* 2004;31:534–7.
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Noninfectious Complications

Hernia

Significant abdominal wall hernias should be surgically repaired prior to the initiation of peritoneal dialysis. The majority of hernias can be repaired at the time of the catheter implantation. Repair of large or complicated hernias may be staged as a separate procedure in advance of catheter placement or accompanied with an embedded catheter approach when an extended healing period is anticipated to minimize risk of recurrence.

Enlargement of the herniation may occur as a result of increased abdominal wall pressure from intraperitoneal dialysate. Significant hernias left untreated increase the risk of further enlargement, pain, bowel entrapment, and subsequent discontinuation of peritoneal dialysis.¹

The most commonly seen hernias are umbilical, inguinal, incisional, and pericatheter. Pericatheter hernias occur more often when the catheter is placed through the midline instead of the paramedian approach through the rectus muscle.

KEY ASSESSMENTS

- Protrusion at umbilicus, inguinal area, genitalia, previous surgical scars, or catheter insertion site
- Presence of genital or abdominal wall edema
- Drainage from umbilical sinus
- Determine reducibility/pain/size
- Evaluate for tenderness and inflammation
- If pericatheter, review catheter placement procedure

KEY ACTIVITIES

- Inspect and examine suspect sites
- Refer to surgeon to determine intervention
- Umbilical hernias may be asymptomatic and can be managed by avoiding large fill volumes
- Schedule patient follow-up

THERAPEUTICS

- Significant hernia requires surgical repair
- Hernias should be repaired with prosthetic mesh techniques to minimize the high risk of recurrence in patients on PD.¹ Until more information is known about resistance to infection of intraperitoneally placed prosthetic materials in the event of PD-related peritonitis, extraperitoneal hernia repair techniques with prosthetic mesh is advised.²
- Appropriate surgical attention to details in producing a watertight peritoneal closure and the use of supine, low-volume intermittent PD permits immediate resumption of therapy after hernia repair and avoids the need for temporary hemodialysis
- Patients have been continued on PD during the postoperative period after hernia repair; use of lower volume exchanges with dry days have allowed for continuation of PD without conversion to temporary HD³

Consider HD backup in patients with no residual renal function in whom small volume frequent exchanges are insufficient to control azotemia

Noninfectious Complications

PATIENT EDUCATION

- Minimize intra-abdominal pressure by avoiding:
 - Straining
 - Coughing
 - Constipation
 - Stair climbing
 - Lifting
- Report increase in size of hernia or pain
- Following surgical repair, instruct patient to maintain separation of exit-site and operative wound dressings to prevent cross-contamination
- Observe for recurrence
- Use of velcro abdominal binder during ambulatory periods following repair of umbilical and midline hernias is suggested
- Instruct in use of alternative perioperative dialysis regimen
 - Supine position during dialysis therapy
 - Initial low-volume intermittent dialysis
 - Dry abdomen during ambulatory periods during first two weeks
 - Volume graduated incrementally over 2 weeks to usual regimen

OUTCOMES EVALUATION

Collect data to include:

- Type of hernia
- Interventions utilized
- Results
- Dialysis prescription alterations

Enter data into catheter management database

References:

1. Crabtree JH. Hernia repair without delay in initiating and continuing peritoneal dialysis. *Perit Dial Int* 2006;26:178–82.
2. García-Ureña MA, Rodríguez CR, Vega Ruiz V. Prevalence and management of hernias in peritoneal dialysis patients. *Perit Dial Int* 2006;26(2):198–202.
3. Shah H, Chu M, Bargman JM. Perioperative management of peritoneal dialysis patients undergoing hernia surgery without the use of interim hemodialysis. *Perit Dial Int* 2006;26:684–7.

Noninfectious Complications

Abdominal Discomfort During Infusion and Drain

KEY ASSESSMENTS

Perform dialysis exchange, inflow and outflow:

- Evaluate patient for the presence, frequency, and degree of discomfort or pain and relation to inflow and outflow
- Monitor dialysis outflow drainage (effluent) for timing, completeness of drain, color, and clarity
- Check dialysis solution temperature
- Rule out peritonitis

KEY ACTIVITIES

Inflow pain can be due to mechanical causes or to the effects of solution temperature or pH. Inflow pain usually subsides gradually after filling is complete. For abdominal discomfort during inflow:¹

- Change position during infusion
- In CAPD patients, reduce dialysis infusion rate by lowering the IV pole or partially closing the transfer set clamp; in APD patients, adjust fill rate or program cyclers to deliver modified tidal (85%–90%)
- Ensure proper warming of dialysis solution
- Treat constipation
- Investigate PD catheter position—flat plate of abdomen
- Reposition PD catheter if unresolved as necessary
- Check shelf life of used dialysis solution
- While addition of small amounts of bicarbonate and lidocaine have been added to solutions to treat infusion discomfort, these additions to the bag are a peritonitis risk and have not been rigorously evaluated

PATIENT EDUCATION

For abdominal inflow discomfort

Teach patient causes and interventions:¹

- Avoid constipation
- Rapid inflow – reduce infusion rate
- Too rapid a transition to larger dialysis fill volumes – slowly increase fill volumes
- Dialysis solution too warm or too cold – warm to body temperature
- Potential cause and interventions for PD catheter malposition
- Training for APD if on manual exchanges as trial of different modality

For abdominal discomfort during outflow

- Leave small amount of dialysate fluid in the peritoneal cavity in patients on CAPD. In APD patients, program cyclers to deliver modified tidal PD (85%–90%)^{2, 3}
- Elevating the drain bag to reduce the distance between the abdomen and drain bag can reduce the syphoning pressure that may create drain discomfort

Noninfectious Complications

OUTCOMES EVALUATION

Collect data to include:

- Duration and degree of discomfort
- Interventions
- Adjustments to dialysis prescription
- Patient tolerance
- Medications prescribed
- Diagnostic tests and results
- Stool records

Enter data into catheter management database

References:

1. Maaz DE. Troubleshooting non-infectious peritoneal dialysis issues. *Neph Nurs J* 2004;31:521–33.
2. Fernando SK, Finkelstein FO. Tidal PD: its role in the current practice of peritoneal dialysis. *Kidney Int* 2006;70:S91–S95.
3. Juergensen PH, Murphy AL, Pherson KA, et al. Tidal peritoneal dialysis to achieve comfort in chronic peritoneal dialysis patients. *Adv Perit Dial* 1999;15:125–6.

Noninfectious Complications

Pneumoperitoneum

Intraperitoneal air may lead to referred pain to the shoulder. Pneumoperitoneum typically occurs due to the inadvertent infusion of air during the instillation of dialysis solution.¹

KEY ASSESSMENTS

- Evaluate degree and duration of shoulder pain
- Interview patient regarding recent infusion of air during exchange procedure
- Rule out pain of cardiac origin
- Assess for bowel perforation

KEY ACTIVITIES

- Send effluent sample for cell count and culture to rule out potential contamination
- Prime PD system according to manufacturer's instructions
- Observe patient/caregiver's exchange procedure to verify adherence to adequate tubing priming
- Perform upright abdominal X-ray to identify PD catheter position and identify sub-diaphragmatic free air in the peritoneal cavity
- Intervention: infuse full exchange volume, then drain dialysate with patient in knee-chest or Trendelenburg position

PATIENT EDUCATION

Proper priming/flushing procedure for PD system:

- For manual systems, always close clamps after infusion of solution

OUTCOMES EVALUATION

Collect data to include:

- Diagnostic testing and results
- Interventions

Enter data into catheter management database

References:

1. Imran M, Bhat R, Anijeet H. Pneumoperitoneum in peritoneal dialysis patients: one centre's experience. *NDT Plus* 2011;4:120–3.

Noninfectious Complications

Hemoperitoneum

Blood loss into the peritoneal cavity will produce cloudy/bloody effluent. As little as a few drops of blood will produce grossly bloody dialysate. The most common cause of hemoperitoneum in women includes retrograde menstruation and ovulation. Mild bleeding can be caused by catheter-induced trauma, strenuous exercise, and the formation of abdominal adhesions.¹ Hemoperitoneum may also present due to retroperitoneal pathology.² Any bleeding, however, needs to be carefully monitored for severity and potential serious causation.

KEY ASSESSMENTS

- Assess for hemodynamic stability with blood pressure and pulse
- Assess general appearance to rule out acuity
- Assess for abdominal pain and any localizing symptoms
- Observe dialysis exchange drain fluid for color and clarity
 - Rule out peritonitis
- Obtain patient history, investigate potential causes including:
 - Status post peritoneal catheter placement
 - In menstruating females, assess menstrual cycle to consider retrograde menstruation or mid-cycle ovulation
 - Inquire regarding any recent procedures: colonoscopy, sigmoidoscopy, cardiac catheterizations²
 - Consider surgical causes such as cholecystitis, rupture of the spleen, or pancreatitis
 - Consider medical causes such as coagulation disorders, polycystic kidney disease, leakage of hematoma outside of peritoneal cavity, post extracorporeal lithotripsy for kidney stones, rupture of ovarian or hepatic cysts, encapsulating peritoneal sclerosis¹
 - Recent use of intraperitoneal tPA

KEY ACTIVITIES

CLINICAL APPROACH TO HEMOPERITONEUM

For postcatheter insertion blood-tinged effluent:

- 500–1000 mL volume flush with heparinized dialysis fluid or saline until drain is clear
- Add heparin 1000 units/L as long as the effluent has visible signs of blood or fibrin to maintain catheter patency
 - Intraperitoneal instillation of heparin does not affect systemic coagulation parameters and does not increase the risk of bleeding.¹ However, it has been reported that heparin may still reach the systemic circulation potentially via lymphatic absorption or with increased peritoneal membrane permeability with peritonitis. Therefore, IP heparin is contraindicated in patients with heparin-induced thrombocytopenia (HIT)¹
- Observe drain fluid color with dialysis exchanges
- Document duration of blood-tinged exchanges and progression (increase/decrease)
- Consider investigating for peritonitis or other acute abdominal issue if prolonged
- Obtain imaging and surgical consultation as required

Noninfectious Complications

PATIENT EDUCATION

- Instruct women of reproductive age about the potential for hemoperitoneum
- Observe dialysis exchanges drain fluid for decreasing color and resolution

Teach patient to:

- Avoid heavy lifting/trauma
- Document frequency, duration, and treatment of bloody effluent
- Bleeding, typically minimal to moderate, may resolve spontaneously

OUTCOMES EVALUATION

Collect data to include:

- Interventions including medications
- Response to intervention
- Alterations in dialysis prescription or schedule

Enter data into catheter management database

References:

1. Lew SQ. Hemoperitoneum: bloody peritoneal dialysate in ESRD patients receiving peritoneal dialysis. *Perit Dial Int* 2007;27:226–33.
2. Balsera C, Guest S. Hemoperitoneum in a peritoneal dialysis patient from a retroperitoneal source. *Adv Perit Dial* 2013;29:69–72.
3. Kaplan GG, Manns B, McLaughlin K. Heparin induced thrombocytopenia – to intraperitoneal heparin exposure. *Nephrol Dial Transplant* 2005;20:2561–62.

Noninfectious Complications

Hydrothorax

Hydrothorax typically presents as a right-sided pleural effusion due to a pleuroperitoneal communication which allows dialysate to enter the pleural cavity.¹ Diagnosis is confirmed by aspirating pleural fluid and determining that the pleural fluid glucose concentration is higher than the plasma glucose.² Alternatively, the diagnosis of pleuroperitoneal fistula can be established with peritoneal scintigraphy showing radioisotope in the thoracic cavity or MRI. Temporary cessation of PD allows for the slow reabsorption of dialysate, but more rapid drainage of the pleural dialysate can be achieved by pleural aspiration procedures such as a thoracentesis.

Hydrothorax may be acquired after heavy exertion or congenital due to innate diaphragmatic defects. If acquired, the hydrothorax may resolve after cessation of PD.³ If congenital, the diaphragmatic defects require repair procedures—most commonly done by video-assisted thoracoscopy.⁴

KEY ASSESSMENTS

Signs and symptoms of pleural effusion:

- Cough or dyspnea
- Chest pain
- Weight gain
- Decreased dialysis drain volumes
- Small pleural effusion may be symptom free
- Acute respiratory distress

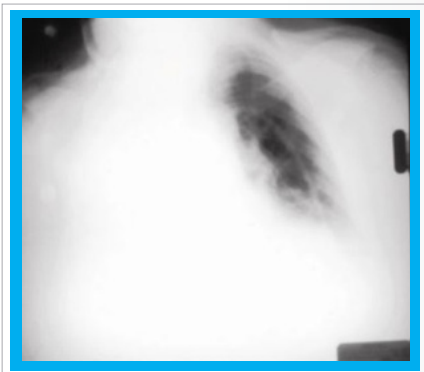
KEY ACTIVITIES

Diagnostic:

- Assess for decreased lung sounds (pleural collection frequently on right side)
- Observe for shortness of breath or cough especially when supine
- Shortness of breath increasing with hypertonic exchanges, especially if drainage amount is decreased
- Chest X-ray showing unilateral pleural effusion, usually right-sided
- Isotope scanning to identify pleural-peritoneal communication can be considered
- Pleural fluid aspirated and tested for glucose and compared to plasma glucose. A pleural fluid to blood glucose ratio > 1 confirms hydrothorax from dialysate.² Aspirated fluid should also have low protein content.
- Conservative management for pleural leakage in the form of peritoneal rest and intermittent low volume dialysis is rarely successful¹
- Temporary hemodialysis for 2–6 weeks usually required to allow pleuroperitoneal communication to seal, especially following pleurodesis³
- Thoracentesis or chest tube drainage with chemical pleurodesis (talc slurry, autologous blood, has been successful³
- Video-assisted thoracoscopic surgery (VATS) may permit visualization of a pleuroperitoneal communication and direct surgical obliteration or directed pleurodesis⁵
- Thoracoscopic pleurodesis with talc poudrage and/or mechanical rub produces 87%–93% success rate in resolving pleural leaks⁵
- Follow-up radiograph to establish closure of pleuroperitoneal communication may be utilized after restarting PD

Noninfectious Complications

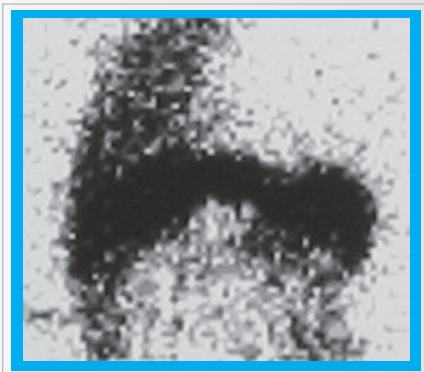
Radiograph courtesy of Steve Guest, MD



HYDROTHORAX

Chest radiograph showing accumulation of dialysate in right hemithorax.

Radiograph courtesy of John Crabtree, MD



PERITONEAL SCINTIGRAPHY

Pleuroperitoneal fistula confirmed with accumulation of radioisotope in the right thoracic space.

PATIENT EDUCATION

- Report physical changes indicating potential leak
- Alter dialysis regimen if required
- Schedule more frequent clinic visits for observation

OUTCOMES EVALUATION

Collect data to include:

- Location of hydrothorax – right vs left side
- Diagnostic testing and results
- Interventions
- Response to interventions

Enter data into catheter management database

References:

1. Guest S. The curious right-sided predominance of peritoneal dialysis-related hydrothorax. *Clin Kidney J* 2015;8:212–14.
2. Momeni N, Colletti PM, Kaptein EM. Low pleural fluid-to-serum glucose gradient indicates pleuroperitoneal communication in peritoneal dialysis patients: presentation of two cases and a review of the literature. *Nephrol Dial Transplant* 2012;27:1212–19.
3. Chow KM, Szeto CC, Li PKT. Management options for hydrothorax complicating peritoneal dialysis. *Semin Dial* 2003;16:389–94.
4. Lang CL, Kao TW, Lee CM, et al. Video-assisted thoracoscopic surgery in continuous ambulatory peritoneal dialysis-related hydrothorax. *Kidney Int* 2008;74:136.
5. Tang S, Chui WH, Tang AWC, et al. Video-assisted thoracoscopic talc pleurodesis is effective for maintenance of peritoneal dialysis in acute hydrothorax complicating peritoneal dialysis. *Nephrol Dial Transplant* 2003;18:804–8.

Noninfectious Complications

Catheter Adapter Disconnect or Fracture of Peritoneal Catheter

KEY ASSESSMENTS

- Observe for dialysis fluid leak from peritoneal catheter or transfer set
- Obtain cell count and culture to rule out peritonitis

KEY ACTIVITIES

- Initiate prophylactic antibiotics¹

For adapter disconnect or catheter fracture:

- Stop dialysis
- Clamp catheter proximal to damage
- If catheter length is adequate, use sterile technique to:
 - Disinfect catheter proximal to damaged area
 - Trim catheter proximal to expanded area on catheter or fracture
 - Using sterile scissors, trim the catheter above area that is damaged or stretched
 - Fit a sterile, new adapter into the catheter
 - Attach transfer set to adapter

If catheter portion is marginal length:

- Repair with appropriate manufacturer's repair kit or catheter extension

PATIENT EDUCATION

Instruct patient to:

- Stop dialysis
- Clamp catheter proximal to damaged spot
- Cover area with sterile dressing
- Go to clinic or emergency room as soon as possible

Teach patient to:

- Secure catheter and transfer set under clothing, avoiding sharp bends in catheter
- Keep sharp objects and tools away from catheter
 - Avoid using scissors to remove catheter dressing
- Avoid using unsuitable disinfectants and soaps on catheter
- Do not use toothed hemostat on catheter
- Avoid using mupirocin cream if catheter is made of polyurethane

OUTCOMES EVALUATION

Collect data to include:

- Type of peritoneal catheter
- Type of perforation
- Intervention
- Response to intervention
- Patient outcome

Enter data into catheter management database

References:

1. Bender FH, Bernardini J, Piraino B. Prevention of infectious complications in peritoneal dialysis: best demonstrated practices. *Kidney Int* 2006[Suppl 70]:S44-54.

section

3

Infectious Complications

This section contains information on adding medications to dialysis solutions. It is important to ensure that the medication and specific dialysis solution are compatible. Please contact dialysis solution manufacturer for more information.

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Infectious Complications: Peritonitis Management

Initial Empiric Management of Peritonitis

The following steps including key assessments, key activities, patient education, and outcomes evaluation are applicable to all peritonitis algorithms shown on subsequent pages.

ISPD guidelines suggest a peritonitis rate of no more than 0.5 episodes per year at risk (1 episode per 24 patient months). Rates of 0.18–0.20 (1 episode per 60–66 patient months) per year¹ have been reported in some centers. The center's overall peritonitis rate should be monitored at a minimum on an annual basis.¹

KEY ASSESSMENTS

The clinical presentation of peritonitis may include any of the following: cloudy effluent, abdominal pain, fever, and acutely declining peritoneal ultrafiltration.

Clinical Diagnosis:¹

- Peritonitis is diagnosed when at least 2 of the following are present:
 - (1) clinical features consistent with peritonitis, i.e., abdominal pain and/or cloudy dialysis effluent;
 - (2) dialysis effluent white cell count $> 100/\mu\text{L}$ or $> 0.1 \times 10^9/\text{L}$ (after a dwell time of at least 2 hours), with $> 50\%$ polymorphonuclear; (3) positive dialysis effluent culture.
- We recommend that PD patients presenting with cloudy effluent be presumed to have peritonitis and treated as such until the diagnosis can be confirmed or excluded.
- We recommend that PD effluent be tested for cell count, differential, Gram stain, and culture whenever peritonitis is suspected.
- WBC count depends on length of dwell; therefore, in APD use %PMN vs absolute WBC count to diagnose peritonitis.
- If patient is dry, instill 1 L of dialysate for a 1–2 hour dwell. Use % PMN for diagnosis.

Differential Diagnosis of Cloudy Effluent:

- | | |
|--|---|
| • Culture-positive infectious peritonitis ² | • Chemical peritonitis ¹ |
| • Infectious peritonitis with sterile cultures ² | • Calcium channel blockers ¹ |
| • recent antibiotic usage ² | • Eosinophilia of the effluent ¹ |
| • technical problems with culture technique ² | • Hemoperitoneum ¹ |
| • unusual organisms (filamentous fungus, mycobacteria, legionella, nocardia, and other fastidious bacteria) ² – infectious causes of cloudy effluent (see Appendix) | • Malignancy (rare) ¹ |
| | • Chylous effluent (rare) ¹ |
| | • Specimen taken from “dry” abdomen ¹ |
| | • Noninfectious causes of cloudy effluent ¹ (see Appendix) |

KEY ACTIVITIES

Initiate the following:

Performed by the PD nurse in the dialysis unit:

- ① Perform physical exam including abdominal palpation, degree and location of pain, exit-site and tunnel assessment
- ② Disconnect drained bag and send sample to laboratory for cell count with differential, Gram stain, and culture. Dwell time should be at least 1–2 hours.¹

Infectious Complications: Peritonitis Management

- Inoculate 2 (aerobic and anaerobic) blood culture bottles with 5–10 mL of effluent (yield enhanced with rapid blood-culture bottle kits)¹
- or
- centrifuge 50 mL PD effluent at 3000g for 15 minutes followed by resuspension of the sediment for inoculation into blood culture bottles¹
- 3 In presence of cloudy effluent with pain and/or fever:
 - Initiate empiric antibiotic therapy as soon as possible while waiting for test results¹
- 4 In presence of cloudy effluent, add heparin 500 U/L to new bag until effluent clears (usually 48 to 72 hours)¹
- 5 Initiate adequate pain management intervention. Peritonitis-related pain may require analgesics for adequate control, which should be prescribed in adequate amounts to control pain appropriately¹
- 6 Assess for need for hospitalization¹
- 7 Review with patient:
 - Discuss possibility of break in technique, compliance to hand washing, mask use
 - Inquire about recent procedures, constipation, diarrhea, and antibiotic use
- 8 Review:
 - Peritonitis and exit-site infection history and treatment
 - Review use of exit-site prophylaxis
- 9 Schedule retraining for technique issues

PATIENT EDUCATION

- Immediately report cloudy effluent, abdominal pain, and/or fever to PD unit
- Save drained cloudy dialysate and bring to clinic
- Stress importance of obtaining specimen prior to beginning antibiotics
- Stress importance of completing 100% antibiotic therapy
- May add heparin 500 U/L to each bag until clear¹
- Report persistent cloudiness to PD unit

OUTCOMES EVALUATION

Collect data to include:

- Date of culture, organism identified, drug therapy used
- Date infection resolved
- Recurrent organisms, date of drug therapy
- Documentation of contributing factors
 - Break-in technique, exit-site infections, tunnel infections
- Date of re-education/training

Enter data into infection tracking tool

Infectious Complications: Peritonitis Management¹

Clinical evaluation
Examine exit-site and catheter tunnel
Collect PD fluid for cell count, differential count, Gram stain, and bacterial culture

Start IP antibiotics as soon as possible
Allow antibiotic to dwell for at least 6 hours
Empirical Gram-positive and Gram-negative coverage based on
patient history and center sensitivity patterns

Gram-positive coverage:
First-generation
cephalosporin[‡] or vancomycin[†]

Gram-negative coverage:
Third-generation
cephalosporin[‡] or aminoglycoside

Consider adjuvant treatment: pain control; IP heparin; anti-fungal prophylaxis.
Education and assess IP injection technique.
Ensure follow-up arrangements.

IP=intra-peritoneal

* Continued assessment and modification of therapy based on culture and sensitivity results; refer to subsequent sections for specific organisms cultured.³ Exchange that contains antibiotics must be a minimum 6-hour dwell.¹

† Vancomycin may be considered if patient has a history of methicillin-resistant *Staphylococcus aureus* colonization/infection, is seriously unwell, or has a history of severe allergy to penicillins and cephalosporins. If the center has an increased rate of methicillin resistance, vancomycin may also be considered.³

‡ If the patient is cephalosporin allergic, aztreonam is an alternative to ceftazidime or cefepime. Vancomycin and ceftazidime are compatible when mixed in a dialysis solution volume greater than 1 L; however, they are incompatible when mixed in the same syringe or empty dialysis solution bag for reinfusion. Aminoglycosides should not be added to the same exchange with penicillins as this results in incompatibility.¹

Infectious Complications: Peritonitis Management

*Staphylococcus aureus*¹

Discontinue initial empiric Gram-negative coverage
Continue Gram-positive coverage based on sensitivities
First-generation cephalosporin – drug of choice

If MRSA vancomycin drug of choice
(teicoplanin and daptomycin are alternatives)
oral rifampin for 5–7 days (may reduce relapse/repeat peritonitis)

Assess clinical improvement, repeat dialysate effluent cell count and culture at days 3–5*

Clinical improvement
• Continue antibiotics;
• Re-evaluate for exit-site or occult
tunnel infection

No clinical improvement
• Reculture and evaluate

No clinical improvement by 5 days on
appropriate antibiotics: remove catheter

If exit sites or tunnel
infection present

Suggest removal of catheter
in peritonitis with
exit-site infection and/or
tunnel infection.

If catheter has been removed,
reinsertion of PD catheter
may be attempted at least 2
weeks after catheter removal
and after complete resolution
of peritoneal symptoms.⁵

Duration of
therapy:
at least 21 days

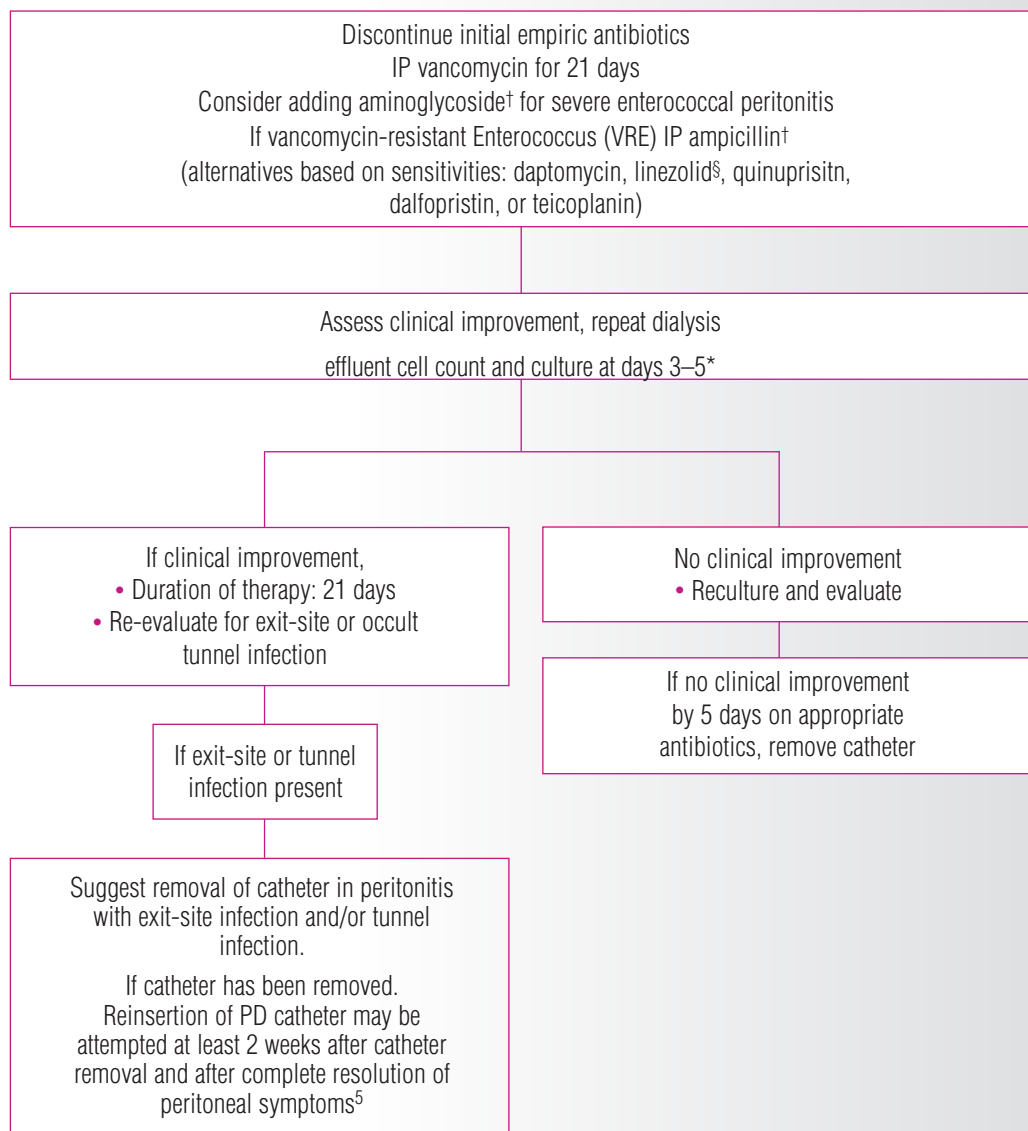
Screen for
S. aureus carrier

Peritonitis resolves
but persistent ESI or
tunnel infection
Consider
simultaneous
catheter removal
and re-insertion

* A day 3 peritoneal dialysate WBC count $\geq 1,000 \text{ mm}^3$ has a 64% likelihood of treatment failure.⁴

Infectious Complications: Peritonitis Management

*Enterococcus Peritonitis*¹



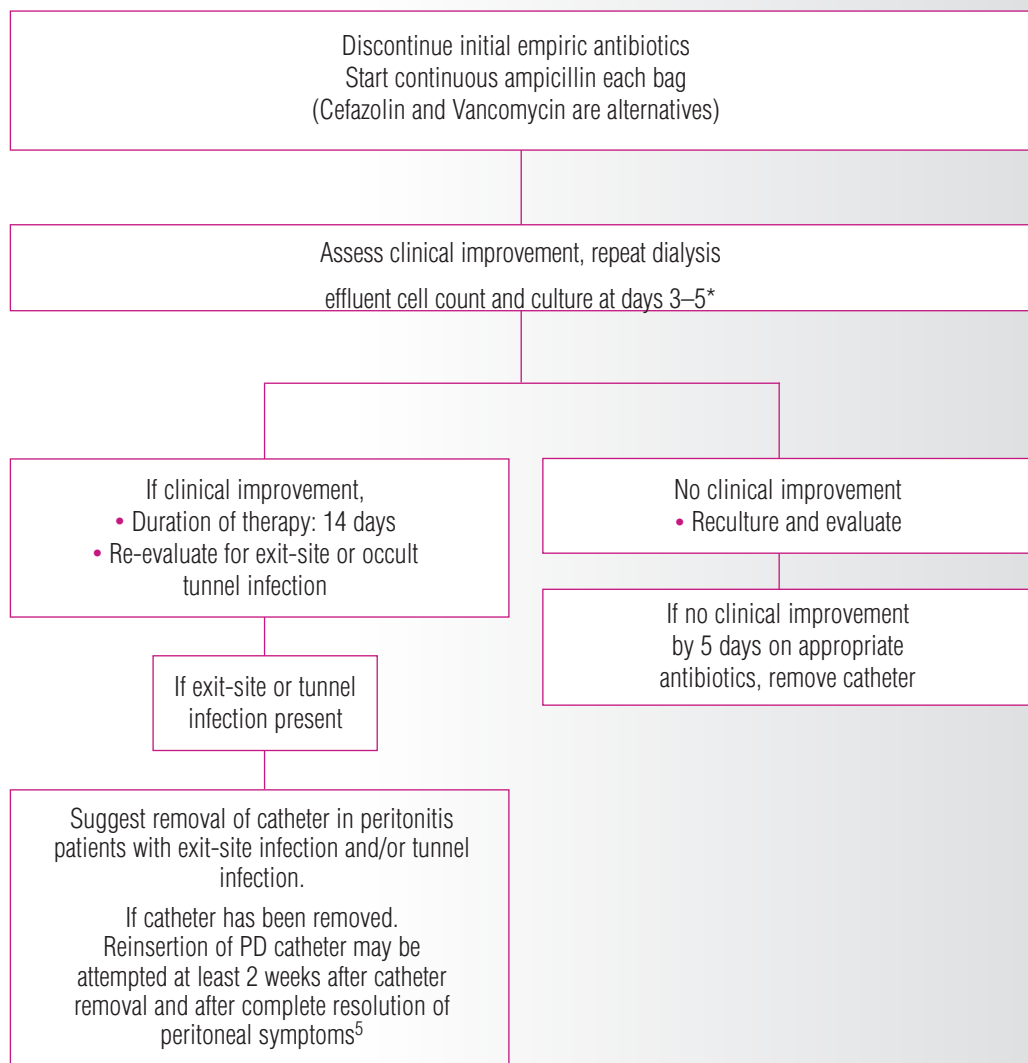
* A day 3 peritoneal dialysate WBC count $\geq 1,000 \text{ mm}^3$ has a 64% likelihood of treatment failure.⁴

[†] Aminoglycosides should not be added to the same exchange with penicillins because of chemical incompatibility.¹

[§] Choice of therapy should always be guided by sensitivity patterns. If linezolid is used for vancomycin-resistant enterococcus, bone marrow suppression has been noted after 10–14 days. Prolonged therapy may result in neurotoxicity.³

Infectious Complications: Peritonitis Management

Streptococcus Peritonitis¹



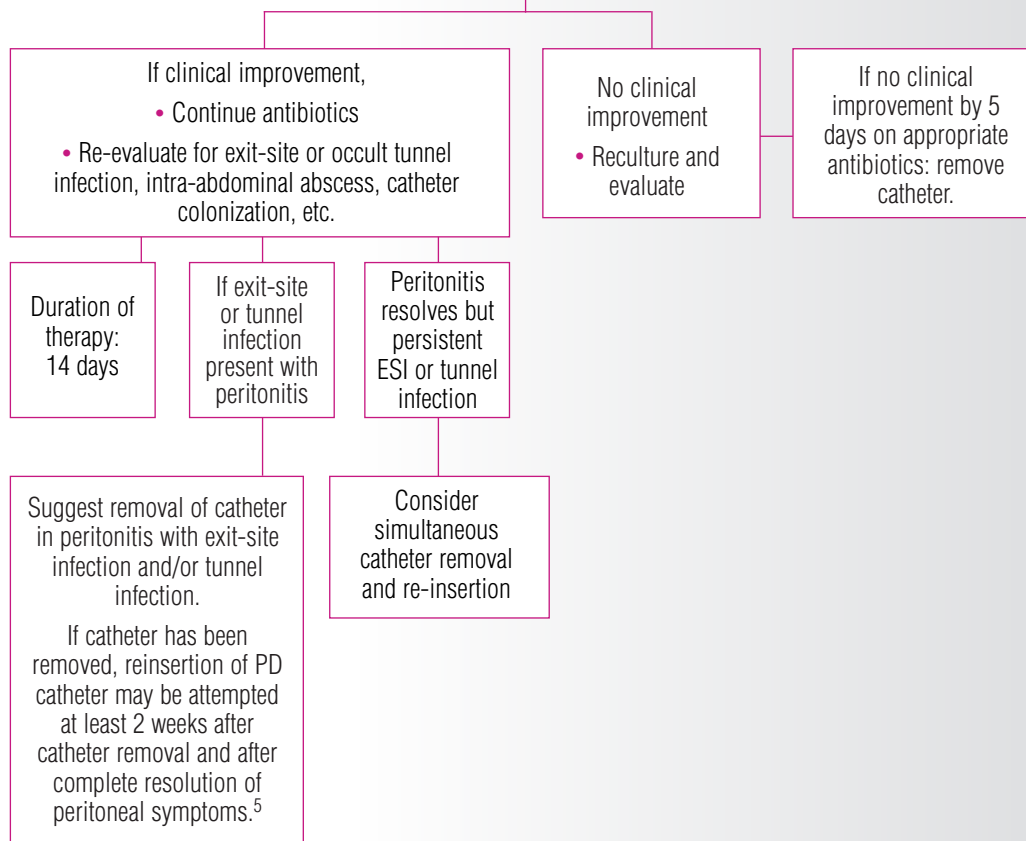
* A day 3 peritoneal dialysate WBC count $\geq 1,000 \text{ mm}^3$ has a 64% likelihood of treatment failure.⁴

Infectious Complications: Peritonitis Management

Coagulase-negative *Staphylococci*¹

Discontinue initial empiric Gram-negative coverage
Continue Gram-positive coverage based on sensitivities (Cephalosporin[†] or Vancomycin)

Assess clinical improvement, repeat dialysis effluent cell count and culture at days 3–5*



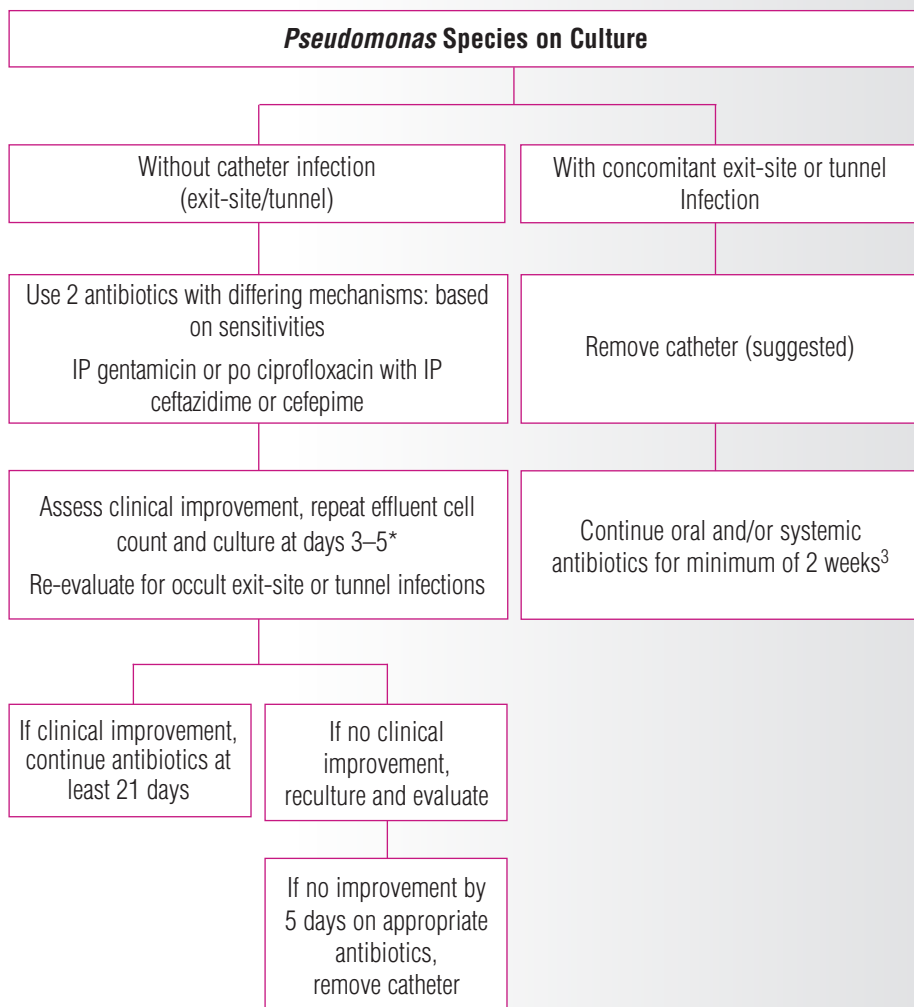
Relapsing Coag neg peritonitis suggest colonization of catheter with biofilm.
Consider catheter removal.

* A day 3 peritoneal dialysate WBC count $\geq 1,000$ mm³ has a 64% likelihood of treatment failure.⁴

† It is important to avoid inadequate IP antibiotic levels, which may lead to relapsing peritonitis. For this reason, continuous dosing of IP first-generation cephalosporins is preferable to intermittent dosing.¹

Infectious Complications: Peritonitis Management

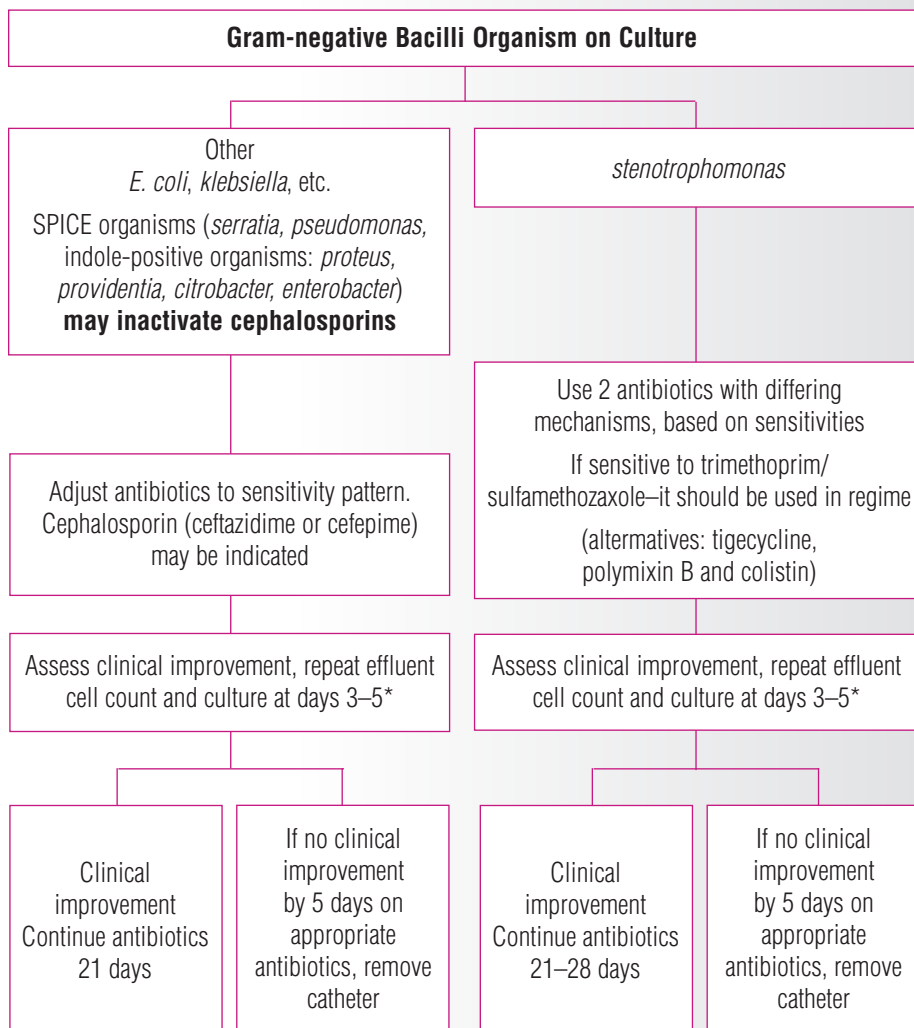
Pseudomonas aeruginosa Peritonitis¹



* A day 3 peritoneal dialysate WBC count $\geq 1,000 \text{ mm}^3$ has a 64% likelihood of treatment failure.⁴

Infectious Complications: Peritonitis Management

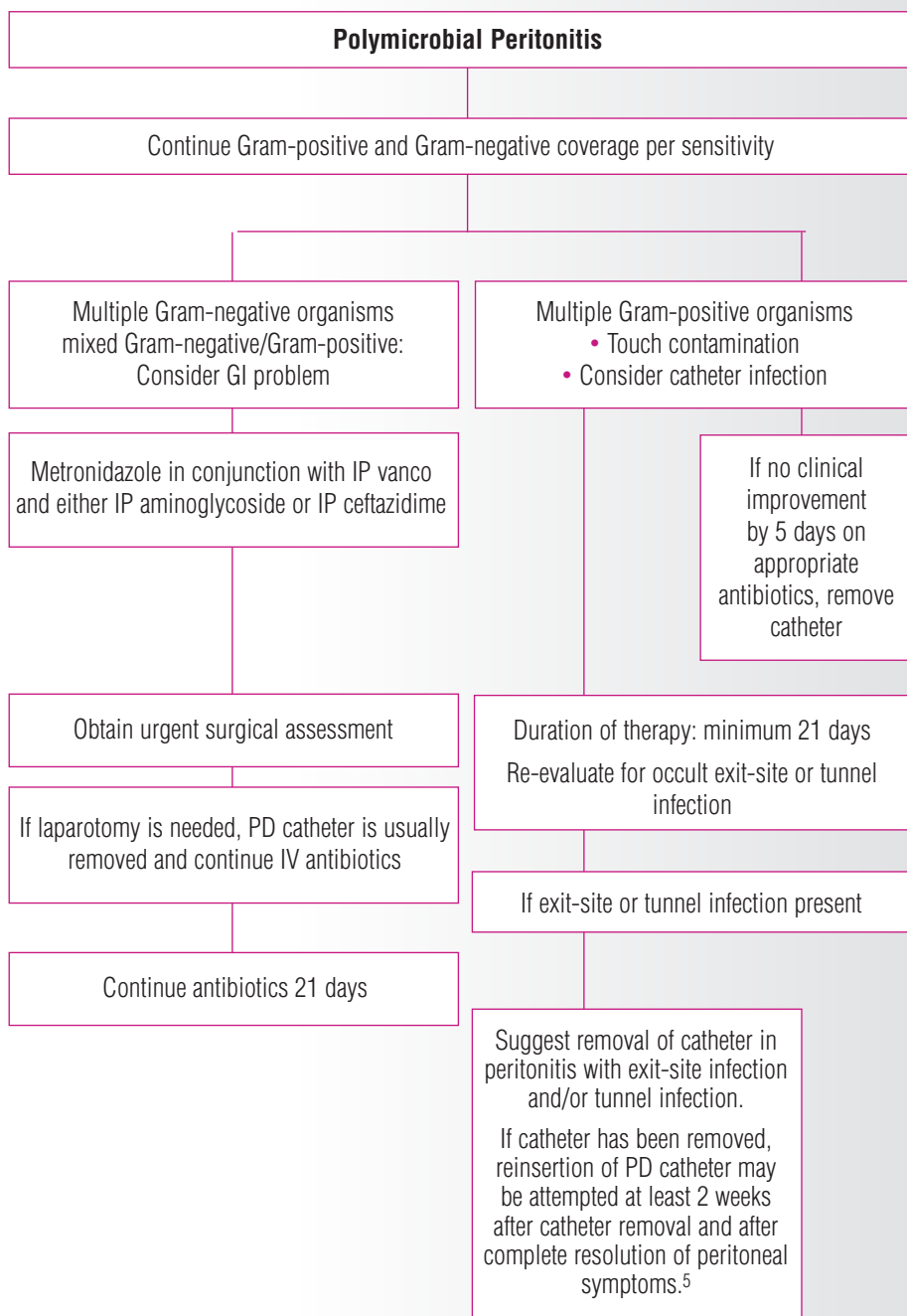
Gram-negative Bacilli Organism Peritonitis¹



* A day 3 peritoneal dialysate WBC count $\geq 1,000 \text{ mm}^3$ has a 64% likelihood of treatment failure.⁴

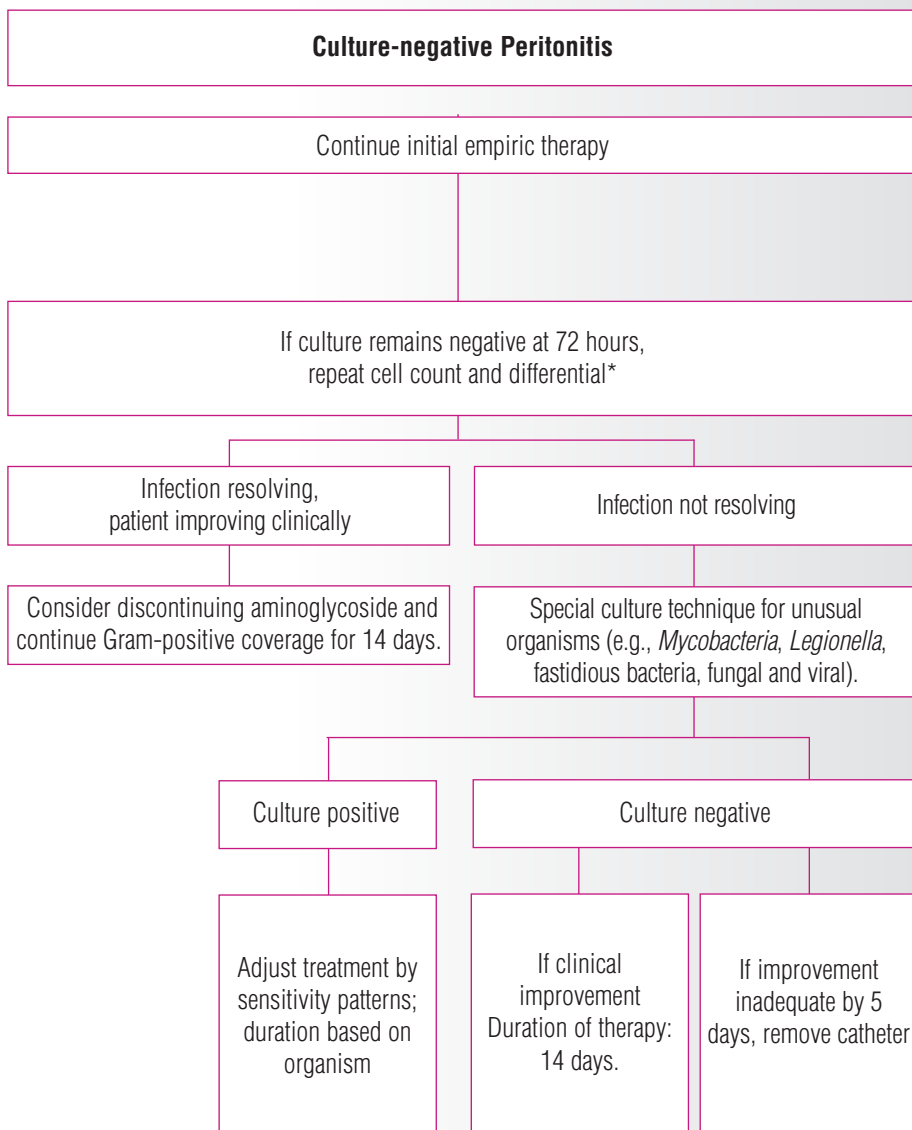
Infectious Complications: Peritonitis Management

Polymicrobial Peritonitis¹



Infectious Complications: Peritonitis Management

Culture-negative Peritonitis¹



* A day 3 peritoneal dialysate WBC count $\geq 1,000 \text{ mm}^3$ has a 64% likelihood of treatment failure.⁴

Infectious Complications: Peritonitis Management

Fungal Peritonitis*

Yeast or other fungus on Gram stain/microscopy³ or culture¹

Remove catheter immediately¹

Initial therapy may be a combination of amphotericin B[†] and flucytosine.^{1**}
Other agents are echinocandins, fluconazole, voriconazole, posaconazole¹

Treat for at least 14 days of anti-fungal agent after catheter removal¹

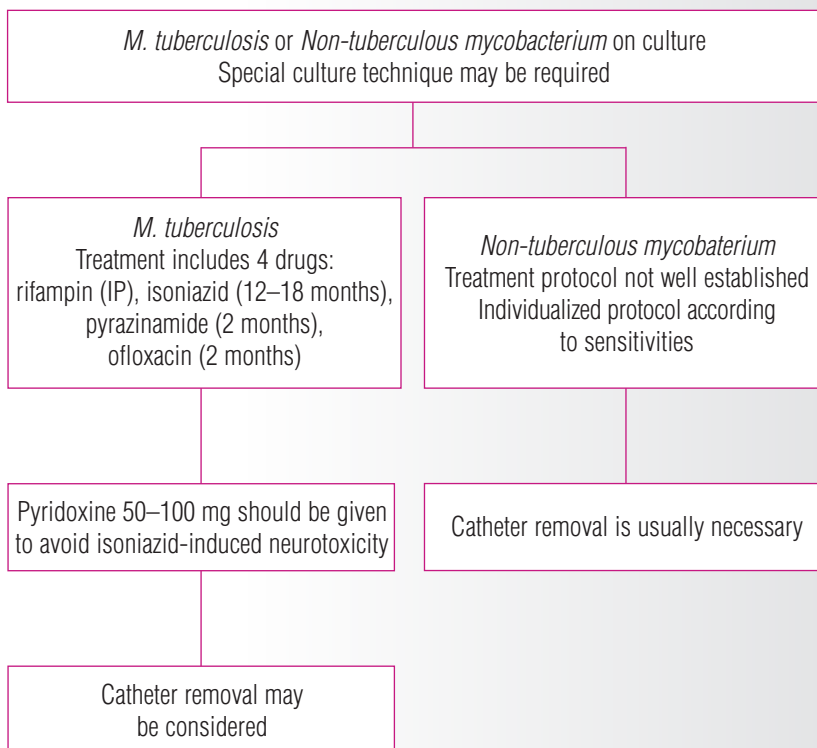
[†] IP amphotericin causes chemical peritonitis and pain, while IV administration has poor peritoneal bioavailability.¹

* Fungal peritonitis is often preceded by courses of antibiotics.¹

** If flucytosine is used, monitor serum concentration levels to avoid bone marrow toxicity (peak serum levels 1–2 hours after dose should be 25–50 mcg/mL)¹

Infectious Complications: Peritonitis Management

Mycobacterium Peritonitis¹



Infectious Complications: Peritonitis Management

Peritonitis Terminology¹

Recurrent Peritonitis

An episode that occurs within 4 weeks of completion of therapy of a prior episode but with a different organism

Relapsing Peritonitis*

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

Repeat Peritonitis*

An episode that occurs more than 4 weeks after completion of therapy of a prior episode with the same organism

Refractory Peritonitis

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

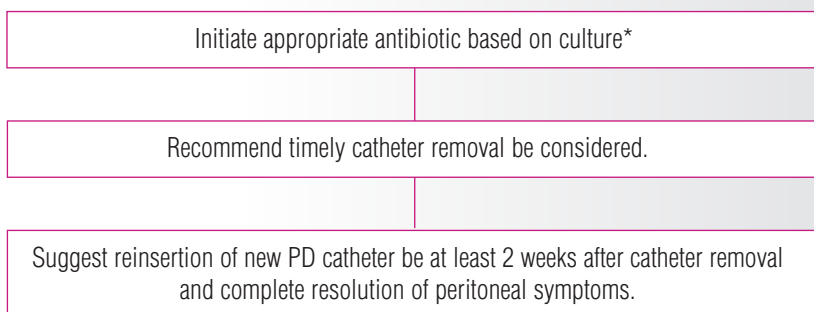
*Relapsing episodes should not be counted as another episode during the calculation of peritonitis rates;¹ recurrent and repeat episodes should be counted.⁶

Infectious Complications: Peritonitis Management

Relapsing and Repeat Peritonitis¹

Relapse is defined as an episode that occurs within 4 weeks of completion of therapy of a prior episode with the same organism or 1 sterile episode.

Repeat is defined as an episode that occurs more than 4 weeks after completion of therapy of a prior episode with the same organism.



* Refer to Empiric Therapy for organism.

Infectious Complications: Management of Exit-Site/Tunnel Infection

“An exit-site infection is defined by the presence of purulent drainage with or without erythema of the skin at the catheter-epidermal interface.”⁵

A tunnel infection is defined as the presence of clinical inflammation or ultrasonic evidence of fluid collection along the catheter tunnel.⁵

KEY ASSESSMENTS⁵

- Purulent discharge from exit-site, spontaneous or expressed from tunnel, cuff or sinus
- Persistent erythema may be precursor to purulent drainage⁵
- Erythema, induration, or tenderness at exit-site or over the tunnel⁵

Possible indications for ultrasound (US) of catheter tunnel:⁵

- initial evaluation of suspected tunnel infection with or without clinical features of tunnel involvement (especially if caused by *S. Aureus*)
- follow-up of exit-site and tunnel infection after antibiotic treatment
- relapsing peritonitis (may be due to an occult tunnel infection)
- Positive culture with normal appearing site may indicate colonization vs infection
- Erythema or skin reaction may be noted following catheter implantation or trauma³
- *Staphylococcus aureus* carrier status/use of prophylaxis⁵
- Compliance with prophylaxis
- Precipitating or contributing conditions (a break in technique, gross contamination, etc.)
- Suboptimal exit-site care
- Exit-site infection with *S. Aureus* and *pseudomonas* are often associate with concomitant tunnel infection⁵

KEY ACTIVITIES

Initiate the following:

- Culture and Gram stain of purulent exudate and/or drainage
 - Experienced PD nurse may express fluid by pressing on the superficial cuff or with a gentle downward pull of catheter
- Initiate empiric antibiotic therapy as indicated by clinical appearance⁵
 - Empiric therapy should include *Staphylococcus aureus* coverage⁵
 - In patients with history of pseudomonas ESI, empiric therapy should include targeted antibiotic therapy⁵
- In the absence of purulence, tenderness, or swelling, consider intensified local care (e.g., hypertonic saline soaks)²
- Monitor and document condition of exit-site, sinus, and tunnel⁵
- Exit-site infection due to *S. aureus* and *pseudomonas* are often associated with tunnel involvement⁵
- If tunnel infection suspected, ultrasound of subcutaneous pathway may be helpful⁵
- Increase intensity of exit-site care and dressing changes⁵
- Retrain patient on appropriate exit-site care⁶
- Close follow-up with patient to evaluate response to treatment plan⁵

Infectious Complications: Management of Exit-Site/Tunnel Infection

PATIENT EDUCATION

- Intensified exit-site care⁵
 - Clean 1 to 2 times a day
 - Avoid toxic agents entering sinus
 - Change cleansing agent if required
- In the case of severe exit-site infection, saline soaks in addition to antibiotics may be used. Add 1 tablespoon of salt to 1 pint (500mL) sterile water. This solution is applied to gauze and wrapped around the exit-site for 15 minutes, 1 to 2 times per day²
- Soften crust and scabs with saline or soap and water
- Never forcibly remove crusts and scabs
- Apply new sterile dressing with each cleansing procedure until infection resolved, even if not routinely used
- Protect exit-site from exposure to organisms and trauma
- Review antibiotic/antacid/food interactions

Note:

- Quinolone absorption may be reduced when given in combination with sevelamer hydrochloride, calcium salts, oral iron preparations, magnesium/aluminum containing antacids, zinc, sucralfate, or milk. Administration should be staggered as much as possible. The quinolone should be administered first, allowing at least 2 hours between each preparation⁵
- Rifampin interacts with many other medications. Patient medication review is warranted before use of rifampin

OUTCOMES EVALUATION

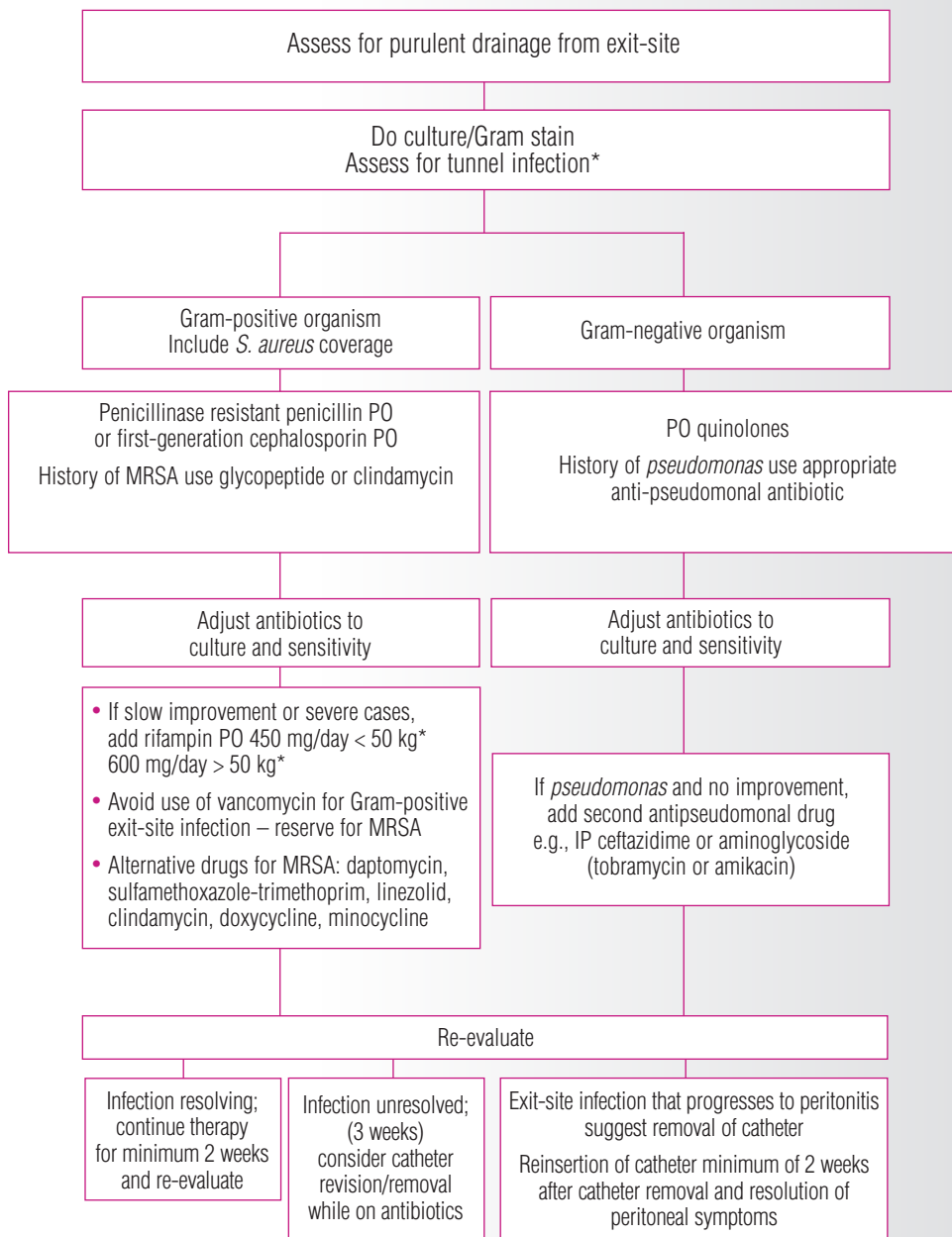
Collect data to include:

- Date of culture, organism identified, drug therapy used
- Date infection resolved (no abdominal symptoms, clear dialysate with normal cell count)
- Recurrent organisms, date of drug therapy
- Date of re-education/training
- Antibiotic prophylaxis regimen used

Enter data into infection tracking tool

Infectious Complications: Management of Exit-Site/Tunnel Infection

Diagnosis and Management of Exit-Site/Tunnel Infection⁵



* Assess for erythema, induration, and tenderness over subcutaneous tunnel. If present, consider diagnosis of tunnel infection. Consider ultrasound of subcutaneous tunnel. ⁵

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3. Li P, Szeto CC, Piraino B, et al. Peritoneal dialysis-related infections recommendations: 2010 update. *Perit Dial Int* 2010;30:393–423.
4. Chow KM, Szeto CC, Cheung KK, et al. Predictive value of dialysate cell counts in peritonitis complicating peritoneal dialysis. *Clin J Am Soc Nephrol* 2006;1:768–73.
5. Szeto CC, Li P, Johnson DW, et al. ISPD catheter-related infection recommendations: 2017 update. *Perit Dial Int* 2017;37:141–54.
6. Piraino B, Bernardini J, Brown E, et al. ISPD position statement on reducing the risks of peritoneal dialysis-related infections. *Perit Dial Int* 2011;31:614–30.
7. Maaz DE. Troubleshooting non-infectious peritoneal dialysis issues. *Neph Nurs J* 2004;31:521–45.

section

4

Antibiotic Dosing Guidelines

Baxter

Antibiotic Dosing Guidelines: Management of Exit-Site/Tunnel Infection

Oral Antibiotics Used in Exit-Site and Tunnel Infections¹

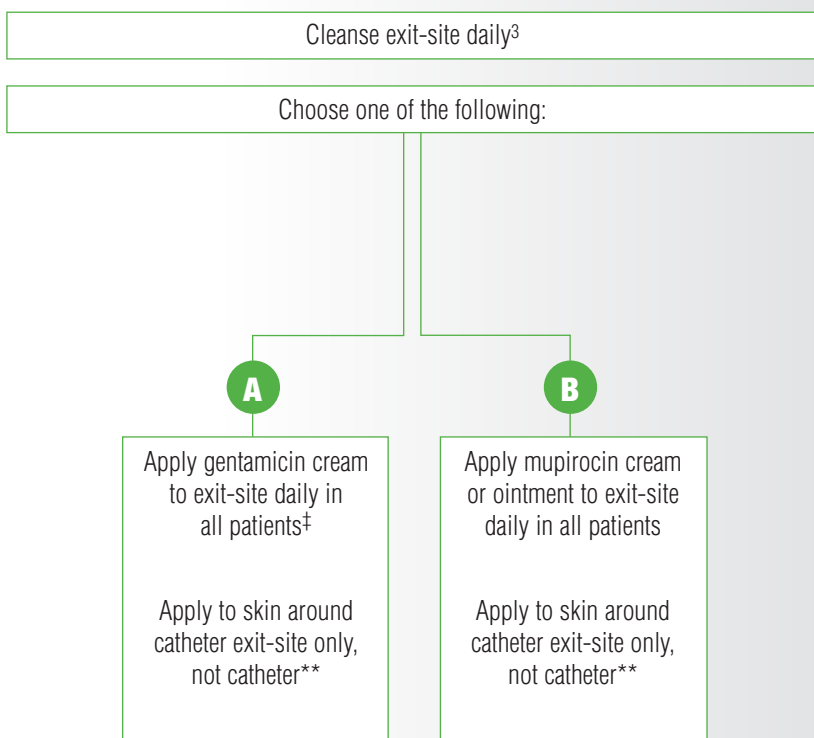
Amoxicillin	250–500 mg BID
Amoxicillin/clavulanate	250mg/125mg–500mg/125mg QD ²
Cephalexin	500 mg BID to TID
Ciprofloxacin	250 mg BID or 500 mg QD
Clarithromycin	500 mg loading, then 250 mg BID
Clindamycin	300–450 mg TID
Cloxacillin/flucloxacillin	500 mg QID
Erythromycin	250 mg QID
Fluconazole	oral 200 mg loading, then 50–100 mg QD
Levofloxacin	300 mg QD
Linezolid	300–450 mg BID
Metronidazole	400 mg QD
Moxifloxacin	400 mg QD
Rifampicin	450 mg QD for BW <50 kg; 600 mg QD for BW ≥50 kg
Trimethoprim/sulfamethoxazole	80 mg/400 mg QD (8) to 60 mg/800 mg BID

Courtesy of Multimed Inc.

mg=milligram; BID=two times per day; QD=every day; kg=kilogram; TID=three times per day; QID=four times per day; BW=body weight

Antibiotic Dosing Guidelines: Exit-Site Prophylaxis

Exit-Site Antibiotic Prophylaxis¹



Important Points¹

- Alternating mupirocin & gentamicin has been associated with increased risk of fungal peritonitis
- Consider keeping catheter immobilized
- Chronic dressing is optional
- Screen for nasal *S. Aureus* carriage prior to PD catheter insertion
If positive treat with topical nasal application of mupirocin

[‡] Gentamicin may be associated with increased non-TB, enterobacteriaceae,¹ and fungal exit-site infections⁵

^{**} Excessive application of antibiotic cream directly to catheter has been reported to cause catheter damage⁴

Antibiotic Dosing Guidelines: Peritonitis Management

Intraperitoneal Antibiotic Dosing Recommendations Studied in CAPD Patients⁶

	INTERMITTENT per exchange, once daily	CONTINUOUS mg per liter, all exchanges
Aminoglycosides		
Amikacin	2 mg/kg	LD 25, MD 12
Gentamicin	0.6 mg/kg	LD 8, MD 4
Netilmicin	0.6 mg/kg daily	MD 10
Cephalosporins		
Cefazolin	15–20 mg/kg	LD 500, MD 125
Cefepime	1000 mg	LD 250–500 MD 100–125
Ceftazidime	1000–1500 mg	LD 500, MD 125
Cefotaxime	500–1000 mg	ND
Ceftriaxone	1000 mg/ day	ND
Penicillins		
Amoxicillin	ND	MD 150
Ampicillin	ND	MD 125
Oxacillin	ND	MD 150
Penicillin G	ND	LD 50,000 u, MD 25,000 u
Quinolones		
Ciprofloxacin	ND	MD 50
Ofloxacin	ND	LD 200, MD 25
Others		
Aztreonam	2 g daily	LD 1000, MD 500 ⁸
Clindamycin	ND	MD 300
Daptomycin	ND	LD 100, MD 20
Imipenem/Cilastatin	500 mg in alternate exchange	LD 250, MD 50
Meropenem	1 gm daily	ND
Polymyxin B	ND	MD 150,000 u (15 mg)
Teicoplanin	15 mg/kg every 5 days	LD 200 MD 20 ⁹
Vancomycin	15–30 mg/kg every 5–7 days*	—
Antifungals		
Voriconazole	2.5 mg/kg daily	NA
Combinations		
Ampicillin/sulbactam	2 g / 1 g every 12 hours	LD 750 MD 100 ¹⁰
Imipenem/cilastatin	500 mg in alternate bags	LD 250, MD 50
Piperacillin/Tazobactam	ND	LD 4gm/0.5gm MD 1gm/0.125gm
Quinupristin/ dalfopristin	25 mg/L in alternate bags (given in conjunction with 500 mg IV BID)	ND

This dosing applies to anuric patients. For dosing of drugs with renal clearance in patients with residual renal function (defined as >100mL/day urine output), dose should be empirically increased by 25%.⁷

ND = no data
LD = loading dose, in mg
MD = maintenance dose, in mg
kg = kilograms

Adapted from Table 5. Courtesy of Multimед Inc.

- * Supplemental doses may be needed for APD pts⁶
- * On day 5, approximately 25% of CAPD patients will not achieve a peritoneal dialysis effluent (PDE) vancomycin concentration greater than 4 mg/L during daytime exchanges. For APD patients in whom dwell times are even shorter (often less than 2 hours), it is likely that an even higher proportion will have "low" PDE vancomycin concentrations for the duration of nighttime treatment.¹¹

Antibiotic Dosing Guidelines: Peritonitis Management

Intermittent Dosing of Antibiotics Studied in Automated Peritoneal Dialysis (APD)⁷

DRUG	Cefazolin
IP DOSE	20 mg/kg IP every day, in long dwell
DRUG	Cefepime
IP DOSE	1 g IP in one exchange per day
DRUG	Fluconazole
IP DOSE	200 mg IP in one exchange per day every 24–48 hours
DRUG	Vancomycin*
IP DOSE	Loading dose 30 mg/kg IP in long dwell, repeat dosing 15 mg/kg IP in long dwell every 3–5 days, following levels (keep trough levels > 15 µg/mL)

IP= intraperitoneal

- * Supplemental doses may be needed for APD pts⁸
- * On day 5, approximately 25% of CAPD patients will not achieve a peritoneal dialysis effluent (PDE) vancomycin concentration greater than 4 mg/L during daytime exchanges. For APD patients in whom dwell times are even shorter (often less than 2 hours), it is likely that an even higher proportion will have “low” PDE vancomycin concentrations for the duration of nighttime treatment.¹¹

Adapted from Table 5. Courtesy of Multimед Inc.

References:

1. Szeto CC, Li P, Johnson DW, et al. ISPD catheter-related infection recommendations: 2017 update. *Perit Dial Int* 2017;37:141–54.
2. Augmentin (package insert). Dr Reddys Laboratories Inc., September 2016. <http://medlibrary.org/lib/rx/meds/augmentin-2/>. Accessed May 31, 2017.
3. Piraino B, Bernardini J, Brown E, et al. ISPD position statement on reducing the risks of peritoneal dialysis-related infections. *Perit Dial Int* 2011;31:614–30.
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11. Fish R, Nipah R, Jones C, Finney H, Fan SL. Intraperitoneal vancomycin concentrations during peritoneal dialysis-associated peritonitis: correlation with serum levels. *Perit Dial Int* 2012;32(3):332–8.

Refer to the manufacturer's package insert for full prescribing information.

section

5

Surgical Salvage Procedures for Infectious Complications

Baxter

Surgical Salvage Procedures for Infectious Complications

Simultaneous Catheter Replacement for Relapsing Peritonitis

KEY ASSESSMENTS

- Relapsing peritonitis: Peritonitis caused by the same genus and species of bacteria that caused the immediately preceding episode or 1 sterile episode and occurring within 4 weeks of completion of antibiotics¹
- Procedure acceptable for peritonitis not due to mycobacteria, fungi, enteric organisms, or pseudomonas species²
- Clinical signs of peritonitis must be resolved and peritoneal leukocyte count is $< 100/\mu\text{L}$ ²

KEY ACTIVITIES

Diagnostic:

- Perform physical exam including abdominal palpation, degree and location of pain, exit-site, and tunnel assessment
- Consider imaging studies for equivocal abdominal exam to evaluate for possible intra-abdominal abscess
- Send sample of peritoneal effluent for cell count

Therapeutics:

- Continue appropriate antibiotic coverage perioperatively²
- Insert new catheter (clean step) before removal of old catheter (dirty step)²
- Close watertight all penetrating points through musculofascial layers of abdominal wall²
- Utilize intermittent regimen of supine, low-volume PD during interval of postoperative recovery;² leave peritoneum dry during ambulatory periods
- Monitor for signs of infection or leak

PATIENT EDUCATION

- Review postoperative instructions (see Patient Education under section on Catheter Insertion and Care)
- Protect new surgical wounds from cross contamination from infected wounds²
- Provide instruction in dressing care of any open surgical wounds
- Review changes in PD technique or modifications inycler settings
- Review antibiotic regimen
- Schedule retraining for PD technique

OUTCOMES EVALUATION

Collect data to include:

- Date of surgical intervention
- Modifications in PD regimen during convalescence
- Date returned to usual dialysis regimen
- Date of retraining
- Wound care employed
- Document outcome to intervention

Enter data into catheter management database

Surgical Salvage Procedures for Infectious Complications

Exit-Site and Tunnel Infections

KEY ASSESSMENTS

- Persistent purulent discharge from exit-site, spontaneous or expressed from tunnel, cuff or sinus despite appropriate antibiotic therapy, and intensified local exit-site care.
- Pain, erythema, tenderness, induration, or swelling over the tunnel³
- Appraise exit-site location. Suboptimal exit-site location may contribute to condition

KEY ACTIVITIES

Diagnostic:

- Perform physical exam including palpation over catheter tunnel to assess for induration, inflammation, and pain, and presence of purulent discharge and/or granulation tissue at exit-site
- Palpation of superficial cuff or gentle downward pull of catheter produces purulent discharge from exit sinus
- Ultrasound imaging of subcutaneous track and Dacron cuffs to assess for fluid around catheter and cuffs³
- Refer to surgeon to determine intervention

Therapeutics:

- Surgical interventions may include unroofing of catheter tunnel with shaving of superficial cuff, catheter splicing procedure to new exit-site location with removal of infected segment of catheter with superficial cuff, or simultaneous catheter replacement^{4,5}
- Infected wounds left open at the time of surgical intervention will require appropriate local care until healed by secondary intention²
- Surgical interventions may be performed without interruption of PD, thereby avoiding temporary HD.⁴ If simultaneous catheter replacement performed, utilize intermittent regimen of supine, low-volume PD during interval of postoperative recovery; leave peritoneum dry during ambulatory periods²
- Continue appropriate antibiotic coverage
- Monitor wound healing

PATIENT EDUCATION

- Protect new surgical wounds from cross contamination from infected wounds
- Provide instruction in dressing care of any open surgical wounds
- Review changes in PD technique or modifications in cycler settings based upon performed surgical intervention
- Review antibiotic regimen

OUTCOMES EVALUATION

Collect data to include:

- Surgical intervention used
- Date of surgical intervention
- Modifications in PD regimen during convalescence
- Wound care employed
- Date infection resolved
- Antibiotic regimen used

Enter data into catheter management database

References

1. Li P, Szeto CC, Piraino B, et al. ISPD peritonitis recommendations: 2016 update on prevention and treatment. *Perit Dial Int* 2016;36:481–508.
2. Crabtree JH, Siddiqi RA. Simultaneous catheter replacement for infectious and mechanical complications without interruption of peritoneal dialysis. *Perit Dial Int* 2016;36(2):182–7.
3. Szeto CC, Li P, Johnson, DW, et al. ISPD catheter-related infection recommendations: 2017 update. *Perit Dial Int* 2017; 37:141–54.
4. Crabtree JH. Peritoneal dialysis catheter splicing for distant relocation of poorly selected exit-sites. *Perit Dial Int* 2005;25:192–5.
5. Crabtree JH, Burchette RJ. Surgical salvage of peritoneal dialysis catheters from chronic exit-site and tunnel infection. *Am J Surg* 2005;190:4–8.

section

6

Appendix

Baxter

Appendix

Preoperative Mapping to Determine the Most Appropriate Catheter Type, Insertion Site, and Exit-Site Location

Since patients come in all sizes and shapes with a variety of medical conditions, one catheter type cannot be expected to fit all. Choice of catheter type should take into consideration the patient's belt line, obesity, skin creases and folds, presence of scars, chronic skin conditions, incontinence, physical limitations, bathing habits, and occupation. It is imperative that the peritoneal dialysis access team, including the surgeon, interventional radiologist, nephrologist, and PD nurse, be familiar with a basic inventory of catheter types to enable customization of the peritoneal access to the specific needs of the patient and to afford maximum flexibility in exit-site location. A poor exit-site location that the patient cannot easily see or take care of predisposes to exit-site and tunnel infection.¹⁻⁴

Often, hospital vendor contracts and purchasing agents determine the kind of peritoneal catheter maintained in stock. Moreover, the type of catheter provided is subject to change without notice. Considering current progress in peritoneal access technology, leaving catheter choice up to nonmedical personnel is unacceptable. The PD team must agree on a basic catheter inventory and insist that these specific items are made available for the peritoneal access procedure. It is impossible for a PD program to develop a dependable protocol for catheter selection if the catheter types and dimensions are constantly changing. In addition, it is essential that each member of the PD access team understands and acknowledges that the preoperative mapping procedure described herein is a definitive and reproducible method that can be performed by any of the team members for selecting the most suitable catheter type, insertion site, and exit-site location.

Preoperative Mapping Using a Catheter Sample

The most appropriate choice of catheter is the one that produces the best balance of pelvic location of the catheter tip, exit-site easily visible to the patient, and can be inserted through the abdominal wall with the least amount of tubing stress. The catheter insertion site is the fulcrum of this best balance and will determine the pelvic position of the catheter tip and the range of reachable exit-sites. Therefore, catheter selection begins with determination of the insertion site. With the patient in the supine position, the insertion site for each style and size of catheter is determined by marking the upper border of the deep cuff in the paramedian plane when the upper border of the catheter coil is aligned with the upper border of the pubic symphysis (Figure 1). For straight-tip catheters, a point 5 cm from the end is aligned with the upper border of the pubic symphysis. If a straight-tip catheter design is preferred, choose a version that provides no more than 15 cm of length below the deep cuff to avoid having excess tubing crowded in the pelvis. During the

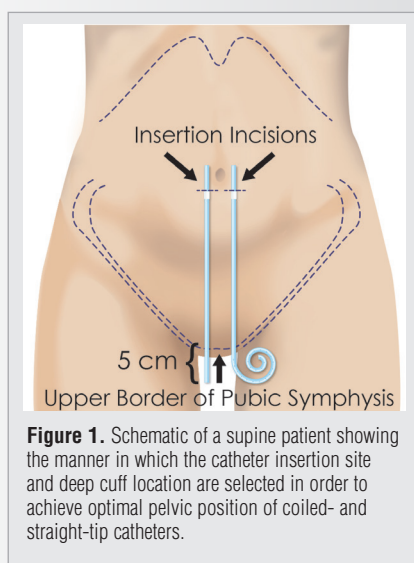


Figure 1. Schematic of a supine patient showing the manner in which the catheter insertion site and deep cuff location are selected in order to achieve optimal pelvic position of coiled- and straight-tip catheters.

Appendix

catheter placement procedure, the deep cuff is implanted within the rectus muscle (or just below) at the level of the insertion incision. Using this convention to determine the insertion site will prevent the catheter tip from being implanted too low in the pelvis, producing pressure or poking discomfort, early termination of dialysate outflow, and severe end of drain pain.⁵

After determining the catheter insertion site, the subcutaneous tunnel path and exit-site location for catheters with a preformed swan neck bend simply follows the configuration of the tubing, marking the skin exit-site 2–3 cm beyond the superficial cuff. Catheters with a straight intercuff segment should assume a gentle arc in the subcutaneous tissues to produce more of a laterally directed exit-site. To enable a gentle arc bend of the straight intercuff tubing segment, choose a catheter version with 5 to 6 cm between the Dacron cuffs. Illustrated in **Figure 2** is a convenient 3-step algorithm for catheters with a straight intercuff segment to design a laterally directed tunnel and exit-site that minimizes creation of excessive tubing stress and shape-memory resiliency forces that can lead to catheter tip migration and superficial cuff extrusion. The inherent properties of this algorithm prevent the superficial cuff from coming any closer than 2 cm of the exit-site, even use in the worst-case scenario of tube straightening.

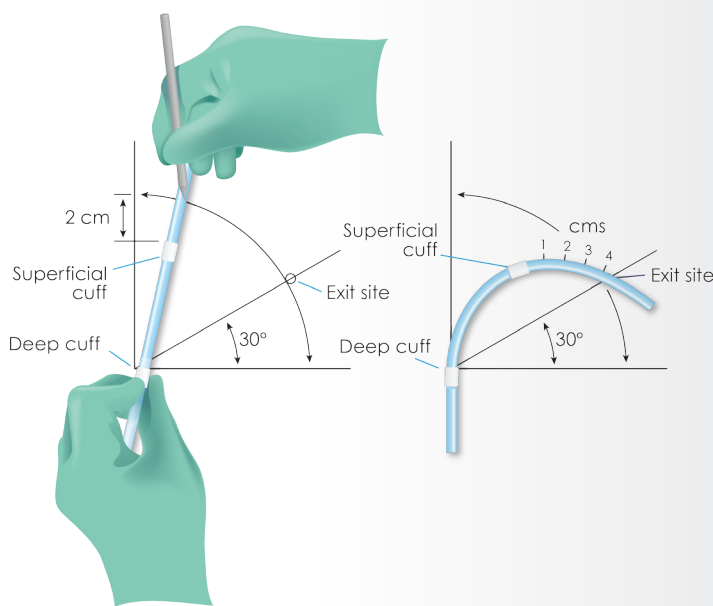


Figure 2. Three-step algorithm for lateral tunnel track and exit-site design. **Step 1:** scribe arc from vertical to horizontal plane using catheter as compass from point 2 cm external of superficial cuff. **Step 2:** mark exit-site at junction of medial 2/3 and lateral 1/3 of arc. **Step 3:** indicate tunnel track shape by bending catheter over from point 4 cm external of superficial cuff to exit-site. (Crabtree JH. Selected best demonstrated practices in peritoneal dialysis access. *Kidney Int Suppl.* 2006;103:S27–37. Figure 10)

If the catheter needs to be bent more than a laterally directed exit-site, a catheter with a preformed swan neck bend should be used instead to eliminate these excessive forces. Upwardly directed exit-sites should be avoided to prevent pooling of cutaneous bacteria and debris, perspiration, and shower water in the exit sinus, predisposing the patient to exit-site and tunnel infection.

After mapping exit-site locations, the patient assumes a sitting position and the marked exit-sites are checked to see which is best visualized by the patient and does not conflict with the belt line, skin creases, or apices of bulging skin folds. If none of the marked exit-sites for the standard abdominal catheters are satisfactory, the patient is then considered for an extended catheter to produce an upper abdominal or presternal exit-site location.

Appendix

Stencil-Based Preoperative Mapping

Marking stencils are provided by some dialysis catheter manufacturers for the most commonly used catheter designs. Properly constructed stencils contain critical catheter design information, including the distance between the deep cuff and the coil, suggested subcutaneous tunnel configurations, and recommended exit-site locations relative to the position of the superficial cuff. Additional features of a well-designed stencil plate permit its precise orientation on the trunk region according to fixed anatomical landmarks, such as the upper edge of the pubic symphysis, representing the anterior upper border of the true pelvis, and the anatomical midline of the torso. Stencils permit accurate and reproducible association of the catheter design elements to these anatomical landmarks to help determine the best catheter style and insertion site that will produce optimal pelvic position of the catheter coil and ideal exit-site location. In addition to the preoperative evaluation, the marking stencil is used again at the time of the catheter placement procedure to retrace the previously determined insertion incision, tunnel configuration, and exit-site location.⁶

Figure 3 demonstrates use of a marking stencil to determine insertion site, tunnel track configuration, and exit-site location for Tenckhoff-style catheters with a straight and preformed swan neck bend in the intercuff tubing segment. With the patient supine, the reference point toward the lower border of the stencil is aligned with the upper border of the pubic symphysis and the medial border of the stencil with the midline of the abdomen (**Figure 3A**).

During preoperative assessment for catheter selection, it is sufficient to only mark the prospective exit-site. At the time of the catheter insertion procedure, the insertion site, tunnel track, and exit-site cutouts on the stencil are marked (**Figure 3B**).

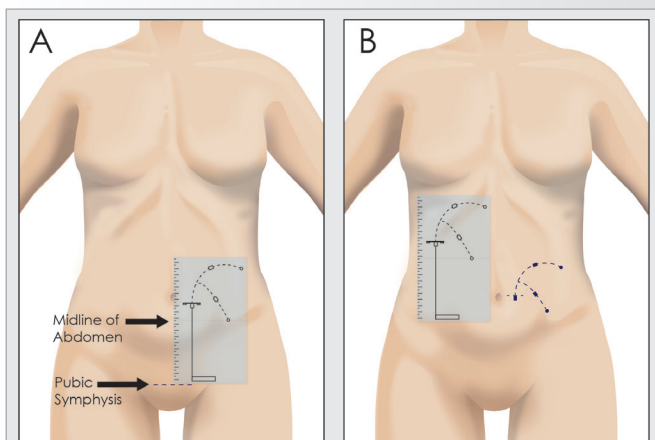


Figure 3A. Mapping using stencil for Tenckhoff catheters with straight and swan neck intercuff segments. With supine patient, align medial border of stencil with midline of abdomen and stencil reference line for pubis with the upper border of the pubic symphysis. Mark exit-sites for both catheter configurations. **Figure 3B.** On day of procedure, mark cutouts for the insertion incision, tunnel configuration, cuff positions, and exit-site location for selected catheter. It is sufficient to mark only the exit-site cutout during preoperative assessment to select catheter type.

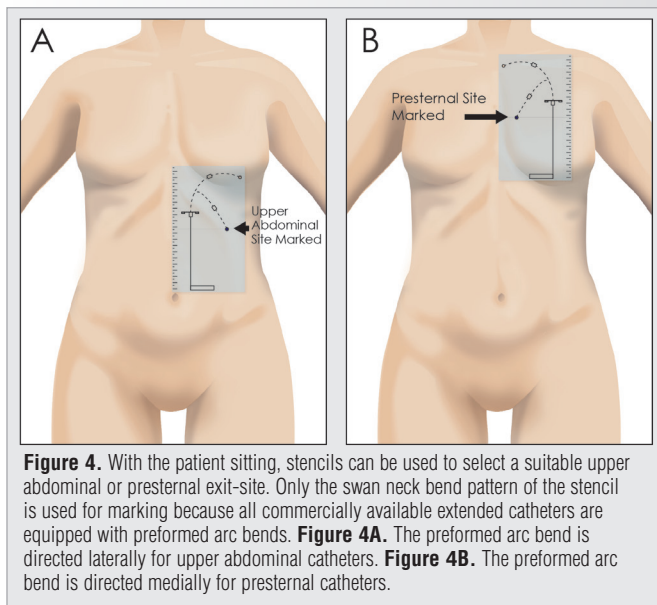
Appendix

Preoperative Mapping for Upper Abdominal and Presternal Catheters

Stencils are exceedingly helpful in determining optimal upper abdominal and presternal exit-site locations. Mapping for an upper abdominal exit-site begins with the patient in a sitting position. The stencil plate possessing cutouts for the secondary incision, tunnel configuration, and exit-site is positioned over the patient's upper abdomen (**Figure 4A**). Align the medial border of the stencil with the midline of the abdomen. Adjust the stencil cranially or caudally until the exit-site cutout is in a position that is easily visible to the patient, does not conflict with belt line or bra line, is free of skin creases or blind side of skin folds, and does not fall on the apex of a bulging or floppy skin fold. Confirm that cutouts for the subcutaneous arcuate tunnel do not conflict with the costal margin. After achieving a suitable location, mark the skin at the exit-site cutout. If a suitable exit-site cannot be obtained, proceed to assessment for a presternal exit-site location.

Mapping for a presternal catheter exit-site is performed with the patient in a sitting position. Female patients should wear their normal bra in order to note the point of rise of the breast mound. The stencil plate, possessing cutouts for the secondary incision, tunnel configuration and exit-site, is positioned over the patient's upper chest (**Figure 4B**). Align the medial border of the stencil with the midline of the chest. Adjust the stencil cranially or caudally until the exit-site cutout is in a position that is not in the open collar area, does not conflict with a possible future midline sternotomy, is free of the fleshy or bulging part of the breast, and does not conflict with the bra line. Confirm that cutouts for the subcutaneous arcuate tunnel do not clash with the clavicle. After achieving a suitable location, mark the skin at the exit-site cutout.

After a satisfactory upper abdominal or presternal exit-site has been marked, the patient assumes a recumbent position. Female patients should remove the bra at this point to duplicate the conditions present during the catheter implantation procedure. Measurements are made, recording the horizontal distance from the marked exit-site to the abdominal or chest midline and the vertical distance from the point of intersection of the horizontal line with the midline to a landmark such as the umbilicus for upper abdominal catheters or the jugular (suprasternal) notch for presternal catheters. Distinctive moles or scars also can be used as landmarks to locate the exit-site. Measure and record the distance from the selected exit-site to these distinguishing marks.



Appendix

Procedure Day Mapping

On the day of procedure in the preoperative holding area or operating room, the exit-site is marked based upon the previous measurements. For standard Tenckhoff catheters, the stencil is superimposed over the denoted exit-site, and the cutouts for the subcutaneous tunnel, superficial cuff location, and insertion incision are marked

(**Figure 3B**). For upper abdominal and presternal catheters, after marking the exit-site and superimposing the exit-site cutout of the stencil over this point, the secondary incision, subcutaneous tunnel, and superficial cuff cutouts are marked (**Figure 5**). For

upper abdominal and presternal catheters, the stencil for the lower abdominal segment of this 2-piece extended catheter is positioned on the abdominal wall. Align the medial border of the stencil with the midline of the abdomen. Adjust the stencil so that the mark for the pubis is superimposed over the palpated upper border of the pubic symphysis. Mark the primary incision site for insertion of the lower abdominal catheter segment (**Figure 5**).

A DVD available from Baxter Healthcare Corporation titled *Implantation Techniques for Peritoneal Dialysis Catheters* demonstrates the process of preoperative mapping using both catheters and stencils.

In addition, construction of stencils for catheters in which none are commercially available is shown.

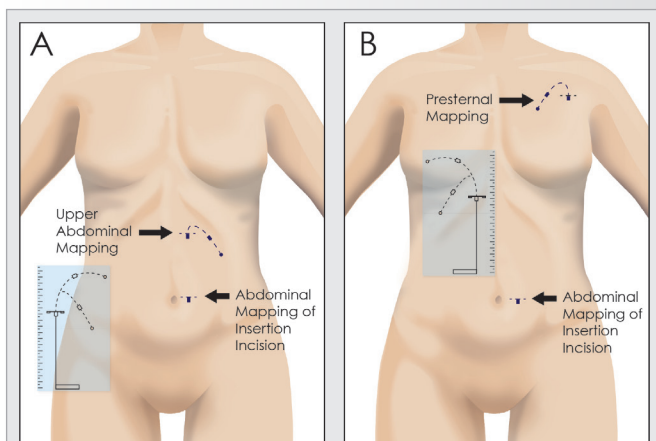


Figure 5A. For upper abdominal catheters, the stencil cutouts for the secondary incision, tunnel configuration, cuff positions, and exit-site location for the upper abdominal catheter segment are marked on day of procedure. In addition, a stencil is used to mark the primary insertion incision for the lower catheter segment.

Figure 5B. For presternal catheters, the stencil cutouts for the secondary incision, tunnel configuration, cuff positions, and exit-site location for the upper chest catheter segment are marked on day of procedure. A stencil is also used to mark the primary insertion incision for the lower catheter segment.

Appendix

References used in this Appendix section

1. Twardowski ZJ, Prowant BF, Nichols WK, Nolph KD, Khanna R. Six-year experience with swan neck presternal peritoneal dialysis catheter. *Perit Dial Int* 1998;18(6):598–602.
2. Crabtree JH. Extended peritoneal dialysis catheters for upper abdominal wall exit-sites. *Perit Dial Int* 2004;24:292–4.
3. Crabtree JH, Burchette RJ. Comparative analysis of two-piece extended peritoneal dialysis catheters with remote exit-site locations to conventional abdominal catheters. *Perit Dial Int* 2010;30(1):46–55.
4. Eriguchi M, Tsuruya K, Yoshida H, et al. Extended swan-neck catheter with upper abdominal exit-site reduces peritoneal dialysis-related infections. *Ther Apher Dial* 2016;20:158–64.
5. Blake P. Drain pain, overfill, and how they are connected. *Perit Dial Int* 2014;34(4):342–4.
6. Crabtree JH. Construction and use of stencils in planning for peritoneal dialysis catheter implantation. *Perit Dial Int* 2003;23(4):395–8.

Appendix

Preoperative and Postoperative PD Catheter Insertion Patient Instructions

It is essential to establish appropriate communication between the surgeon and the nephrology/dialysis clinic during preparation and follow-up to PD catheter placement.

A variety of procedures exist for catheter insertion. Your patient should always consult your individual healthcare practitioner for his or her specific recommendations.

The instructions below may offer your patients guidance during the process of planning, PD catheter placement, and follow-up with their healthcare team in order to assure both patient education and successful outcomes during initial access placement.

Before Surgery

The catheter placement procedure will be thoroughly explained. Marking of the catheter site (determination of the optimal location, i.e., away from the belt line, within easy reach and sight, right or left side) may be completed at this time. Questions and concerns will be addressed.

Shower with a disinfectant soap, as directed: _____

Do not eat or drink after: _____

Bowel preparation (if required): _____

Alert the surgeon/doctor of any known hernias: _____

Medications:

Take: _____

Do not take (hold): _____

Adjust dosage: _____

Antibiotics: _____

Report any unusual cough, fever, chills, or ill feelings prior to surgery.

Date of catheter placement: _____

Report to (location): _____

Please notify the dialysis clinic when your catheter surgery has been scheduled.

Additional instructions/notes: _____

Appendix

After Surgery

- Report any of the following to your surgeon/doctor:
 - Bleeding
 - Fever
 - Vomiting
 - Severe cough
 - Severe pain
 - Wet or dirty/soiled dressing
 - Dressing falls off

Emergency Contact: _____

- The surgical dressing SHOULD BE LEFT IN PLACE FOR AT LEAST 7 DAYS
- The dressing should only be changed by your doctor or nurse at the dialysis clinic
- Do not shower or bathe until advised by the dialysis clinic that the exit-site is healed
- Avoid heavy lifting, stair climbing, straining, and constipation. Your activities for the next few weeks should be light
- Resume all routine medications and diet as instructed by your doctor
- Talk with the surgeon about the need for pain medication
- If antibiotics are ordered, take as directed until they are gone
- Call your dialysis clinic to schedule your follow-up appointment

The telephone number is: _____

Appendix

Peritoneal Imaging

Various imaging techniques can be used to diagnose suspected dialysate leaks into the subcutaneous tissue, pleural cavity, retroperitoneal space, or the genitals. Computerized tomography (CT) imaging peritoneography, peritoneal scintigraphy, or magnetic resonance imaging (MRI) can be used to confirm abnormal dialysate locations.^{1, 2, 3} CT and scintigraphy involve the addition of either CT contrast material into the dialysate or a radioactive isotope. After injection of the contrast material or isotope into the dialysate and the dialysate is allowed to dwell, the radiographic images are obtained to assist in diagnosis. With MRI no contrast agent is required as the dialysate itself brightly enhances during MRI. This information is important in order to localize the leakage site and to assist the surgeon if surgical intervention is necessary. Peritoneal imaging can also be used to identify fluid loculation, a result of peritoneal adhesions.

Note: Communicate the purpose of the test to the radiologist and review radiographs personally. It is advisable to coordinate the diagnostic study with the PD nursing staff to perform the addition of the imaging marker to the dialysate and to make the tubing connections to prevent contamination of the catheter by healthcare personnel who may be unfamiliar with dialysis technique.

CT Peritoneography:¹

Procedure:

- Add 80 mL of water soluble contrast media (80 mL OMNIPAQUE 350) to 1.5 L of dialysis solution
- Infuse dialysis solution with radiocontrast into supine patient
- Instruct patient to move and walk to promote intraperitoneal mixing and to raise intra-abdominal pressure to drive the contrast into the source of the leak

If pleuroperitoneal fistula is suspected, CT should include the chest. If scrotal swelling has been noted, the examination should include this area, otherwise avoid radiation of the testes.

Peritoneal Scintigraphy:²

Procedure:

- Add 2 mCi of technetium-99m sulfur colloid to 2 L of dialysis solution
- Infuse radionuclide-containing dialysate into supine patient with anterior dynamic images obtained at 1 frame per minute for 15 minutes
- Instruct patient to move and walk for 30–60 minutes to promote intraperitoneal mixing and to raise intra-abdominal pressure to drive the radiotracer into the source of the leak
- Obtain 5-minute postambulatory static images in anterior, posterior, and both lateral views
- Drain dialysate from peritoneal cavity and repeat 5-minute static images in anterior, posterior, and both lateral views

Include chest if pleuroperitoneal fistula is suspected. Include inguinal region if scrotal swelling has been noted.

Appendix

Magnetic Resonance Imaging (MRI):³

No contrast is required. Patient is allowed to dwell the dialysate exchange while positioned in the MRI scanner. Images are obtained of suspected area of leakage using T2-weighted images.

References used in this Appendix section

1. Litherland J, Lupton EW, Ackrill PA, Venning M, Sambrook P. Computed tomographic peritoneography: CT manifestations in the investigation of leaks and abnormal collections in patients on CAPD. *Nephrol Dial Transplant* 1994;9(10):1449–52.
2. Juergensen PH, Rizvi H, Caride VJ, Kilger AS, Finkelstein FO. Value of scintigraphy in chronic peritoneal dialysis patients. *Kidney Int* 1999;55(3):1111–9.
3. Prischl FC, Muhr T, Seiringer EM, et al. Magnetic resonance imaging of the peritoneal cavity among peritoneal dialysis patients, using the dialysate as “contrast medium”. *J Am Soc Nephrol* 2002;13:197–203.

Appendix

Principles of Accurate Peritoneal Dialysis Effluent Sampling and Culturing

Identifying appropriate antibiotic therapy is dependent on accurate specimen collection and microbiological diagnosis of peritonitis.

Key Points for Specimen Processing:

- Culture should be obtained as early as possible
- The first bag of cloudy solution is the best specimen, as the probability of a positive diagnostic culture is the greatest
- Patients or PD staff should send the first cloudy bag or an aliquot thereof to the laboratory as quickly as possible
- While delay of several hours from time of collection to time of culture does not decrease accuracy of bacteriological diagnosis, it is preferable to expedite this process
- As large a volume (20 to 100 mL) as possible should be cultured or concentrated to maximize bacterial recovery rates
- Draw fluid from medication port
- Blood culture techniques are considered most optimal
- Inject fluid into standard blood culture medium (5–10 mLs required per bottle)
- The collection and processing of specimens require meticulous care in order to avoid contamination of the fluid
- Laboratory should be notified of specimens obtained from patients receiving antibiotic therapy, as they may require special handling
- Identification and sensitivity testing should be expedited to facilitate initiation of specific antibiotic therapy

Sterile or Culture-negative Peritonitis:

- Incidence of sterile peritonitis varies from 2% to 20% and is more common when the laboratory facility does not have experience in processing peritoneal dialysis effluent
- Other factors contributing to a high incidence of sterile peritonitis include:
 - Insufficient culture sample volume
 - Causative organism difficult to culture
 - Causative organism requiring specialized culture media (i.e., mycobacteria)
 - Patient may not have informed PD center of current antibiotic treatment
 - Patient's signs and symptoms related to other medical condition (i.e., pancreatitis)

References used in this Appendix section

1. Li PK, Szeto CC, Piraino B, et al. Peritoneal dialysis-related infectious recommendations: 2010 update. *Perit Dial Int* 2010;30(4):393–423.
1. Li PKT, Szeto CC, Piraino B, et al. ISPD peritonitis recommendations: 2016 update on prevention and treatment. *Perit Dial Int* 2016;36:481–508.

Appendix

Peritoneal Effluent Culture Laboratory Processing

The correct microbiological culturing of peritoneal effluent is of utmost importance to establish the microorganism responsible for the infection. Identification of the organism and subsequent antibiotic sensitivities will not only help guide antibiotic selection, but, in addition, the type of organism can indicate the possible source of the infection. Culture-negative peritonitis rates should not be more than 20% of episodes. Standard culture technique is the use of blood culture bottles, but culturing the sediment after centrifuging 50 mL of effluent may lower the risk of a culture-negative occurrence.

Procedure:

- Centrifuge 50 mL of peritoneal effluent at 3000 g for 15 minutes
- Follow centrifugation with resuspension of the sediment in 3 to 5 mL of sterile saline
- Inoculate this material both on solid culture media and into a standard blood-culture medium (method most likely to identify the causative organisms; with this method, less than 5% will be culture-negative)
- The solid media should be incubated in aerobic, microaerophilic, and anaerobic environments
- Blood-culture bottles can be directly injected with 5–10 mL of effluent if equipment for centrifuging large amounts of fluid is not available (this method generally results in a culture-negative rate of 20%)
- The removal of antibiotics present in the specimen may increase the isolation rate if the patient is already on antibiotics

Important Points:

- The speed with which bacteriological diagnosis can be established is very important
- Concentration methods not only facilitate correct microbial identification but also reduce the time necessary for bacteriological cultures to turn positive
- Rapid blood-culture techniques (e.g., BACTEC, **SEPTI-CHEK**, BacT/ALERT) may further speed up isolation and identification. A resin culture bottle should be used if patient is on antibiotics or antibiotics were discontinued less than 24 hours prior to culture
- The majority of cultures will become positive after the first 24 hours and, in over 75% of cases, diagnosis can be established in less than 3 days

Mycobacterium Examination:

- Examine smear of the peritoneal effluent with the Ziehl-Neelsen stain ("smear-negative" disease is common)
- The sensitivity of the smear examination by the Ziehl-Neelsen technique can be enhanced by centrifuging 100–150 mL of the dialysate sample
- Prepare smear from the pellet
- A specific diagnosis can be made by culturing the sediment, after centrifugation of a large volume of effluent (50–100 mL), using a solid medium (such as Lowenstein-Jensen agar) and a fluid medium (SEPTI-CHEK, BACTEC; Becton Dickinson; etc.)
- The time of detection for growth of mycobacteria is decreased considerably in fluid medium
- Repeat microscopic smear examination and culture of dialysis effluent is mandatory for better yield in suspected cases of mycobacterial peritonitis

Appendix

References used in this Appendix section

1. Li PK, Szeto CC, Piraino B, et al. Peritoneal dialysis-related infectious recommendations. 2010 update. *Perit Dial Int* 2010;30(4):393-423.
2. Li PK, Szeto CC, Piraino B, et al. ISPD peritonitis recommendations: 2016 update on prevention and treatment. *Perit Dial Int* 2016;36:468-508.

Appendix

Peritonitis Rate Calculations

The most accurate peritonitis rate is one that is cumulative over a period of 12 months. Measuring peritonitis rates both for the individual patient and PD facility provides insight into the peritoneal dialysis outcomes leading to interventions that may improve results. Knowing peritonitis rates also allows for intercenter comparisons at different time points.

METHOD 1: Peritonitis Rate: One episode per number of patient months¹

step 1

Total number CAPD/APD patient days at risk/30.4 days per month = patient months experience

Example: 2,000 days/30.4 days per month = 65.8 months experience

step 2

Number of patient months/number of episodes of peritonitis = 1 episode per number of patient months

Example: 65.8 months/2 episodes = 32.9 or 1 episode every 32.9 patient months

METHOD 2: Peritonitis Rate: Episodes per patient year¹

step 1

Total number CAPD/APD patient days at risk/365 days per year = patient years experience

Example: 2,000 days/365 days per year = 5.5 years experience

step 2

Number of episodes of peritonitis/number of years experience = Episodes per patient year

Example: 2 episodes peritonitis/5.5 patient years = 0.36 episodes per patient year

Important points:

- Include hospital days (once home therapy begins) in total days at risk
- Include hospital acquired peritonitis (once home therapy begins) in total peritonitis rate²
- Relapsing episodes of peritonitis are counted as a single episode of peritonitis²
- Recurrent peritonitis is a new episode of peritonitis and should be counted as an individual occurrence²
- Peritonitis rates should be no more than 0.5 episodes per year at risk (one episode per 24 patient – months) per ISPD 2016 recommendations²
- Programs should also be aware of the percentage of patients who are peritonitis free to include in unit's quality management programs
- Exit-site infection rates are calculated in the same manner as above

Appendix

Calculating Peritonitis Rates: An Example

XYZ Dialysis Center has the following 1st quarter patient census:

January 1–January 31	20 patients = 20 pt x 31 days = 620 patient days for January
February 1–February 28	20 patients = 20 pt x 28 days = 560 patient days
February 5–February 28	1 new patient started PD 2/5 = 1 pt x 24 days = 24 patient days
February 10–February 28	2 new patients started PD 2/10 = 2 pts x 19 days = 38 patient days 560 + 24 + 38 = 622 patient days for February
March 1–March 31	23 patients = 23 pt x 31 days = 713 patient days
March 12–March 31	2 new patients started 3/12 = 2 pt x 20 days = 40 patient days
March 21–March 31	2 new patients started 3/21 = 2 pt x 11 days = 22 patient days 713 + 40 + 22 = 775 patient days for March

Total patient days for 1st quarter: 620 + 622 + 775 = 2017 pt days at risk

Total number of peritonitis episodes during 1st quarter: 2

To calculate peritonitis rates in episodes per patient month:

Take patient days at risk, $2017 \div 30.4$ (days per month: comes from 365 days/12 months) = 66.34 patient months experience

Take patient months experience, $66.34 \div 2$ (number of peritonitis episodes) = 33.17

So the peritonitis rate for the first quarter is: 1 episode every 33.17 patient months

To calculate peritonitis rate in episodes per patient year:

Take patient days at risk, $2017 \div 365$ (days per year) = 5.52 patient years experience

Take the number of peritonitis episodes, $2 \div 5.52$ (patient years experience) = .36

So the peritonitis rate for 1st quarter is: 0.36 episodes per patient year

References used in this Appendix section

1. Li PK, Szeto CC, Piraino B, Bernardini J, et al. Peritoneal dialysis-related infections recommendations: 2010 update. *Perit Dial Int* 2010; 30(4):393-423.
2. Li PK, Szeto, CC, Piraino, B, et al. ISPD peritonitis recommendations: 2016 update on prevention and treatment. *Perit Dial Int* 2016; 36:481-508.

Appendix

Differential Diagnosis of Non-infectious Cloudy Effluent

Cellular causes

1 Increased neutrophils

- Intra-abdominal pathology
 - Cholecystitis¹
 - Appendicitis¹
 - Bowel ischemia¹
 - Pancreatitis¹
 - Organ infarction¹
- Drug associated¹
 - Amphotericin B¹
 - Vancomycin¹
- Contamination of PD fluid
 - Endotoxin¹
- Specimen from “dry” abdomen

2 Increased eosinophils²

- Allergic reaction to sterilant or plasticizer
 - Tubing/transfer sets
 - Dialysis solution bags
 - Peritoneal catheter
- Intraperitoneal air
- Drug associated
 - Vancomycin
 - Gentamicin
 - Cephalosporins

3 Increased erythrocytes

- Any cause of hemoperitoneum
- Retrograde menstruation²
- Ovulation²
- Ovarian/hepatic cyst rupture²
- Peritoneal adhesions²
- Strenuous exercise²
- Catheter-associated trauma²

4 Increased malignant cells

- Lymphoma²
- Peritoneal metastases²

Appendix

Noncellular causes

5 Increased fibrin

- Post peritonitis
- Starting PD

6 Increased triglycerides^{1, 2}

- Acute pancreatitis
- Neoplasms/lymphoma
- Superior vena cava syndrome
- Drug associated
 - Calcium channel blockers
- Chylous ascites

References used in this Appendix section

1. Teitelbaum I. Cloudy peritoneal dialysate: it's not always infection. *Contrib Nephrol* 2006;150:187–94.
2. Rocklin MA, Teitelbaum I. Noninfectious causes of cloudy peritoneal dialysate. *Semin Dial* 2001; 14:37–40.

Appendix

Providing for a Safe Environment for Peritoneal Dialysis

Prevention of exit-site infections and peritonitis requires that both clinicians and patients understand and practice aseptic technique. In the course of daily practice, staff must demonstrate and teach patients how to recognize the potential sources of contamination and to practice measures that will decrease the risk of infection. These preventative measures will reduce complications and promote positive patient outcomes.

Recommendations for a Safe and Clean Environment:

- Prior to each exchange, clean the work area
- The exchange area must:
 - Be well-lit and private
 - Have no open windows or doors
 - Have fans and air conditioners turned off
 - Be free of pets
- For handwashing, use soap and/or alcohol-based products, followed by thorough drying with paper towels
- The patient and partner or nurse must wear a face mask when performing exit-site care and dialysis exchange procedures
- Do not touch STERILE areas of the PD system including:
 - Open solution port of the new bag
 - Tip of the exposed transfer set
 - Connections of the twin bag/"Y" set/cycler set
 - Interior of the MINICAP disconnect cap or connection shield and TWIN BAG system
- Encourage the patient to practice good hygiene
- Perform connections of PD/APD sets to solution bags and transfer sets using aseptic technique each time an exchange is performed
- Use only clean and dry port clamps. Wash clamps with soap and water. Let outlet port clamps dry with open end facing downward

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Appendix

Normal Bacterial Flora of the Human Body

Nose, Mouth, and Upper Respiratory Tract

- *Staphylococcus aureus* (Gram-positive)¹
- *Staphylococcus epidermidis* (Gram-positive)¹
- *Streptococcus* species (Gram-positive)¹
- *Fusobacterium* species (Gram-negative)¹
- *Actinomyces* species (Gram-positive)²
- *Corynebacterium diphtheriae* (Gram-positive)³
- *Haemophilus* species (Gram-negative)¹
- *Non-pathogenic Neisseria* species¹
(Gram-negative)

Skin

- *Staphylococcus aureus* (Gram-positive)¹
- *Staphylococcus epidermidis* (Gram-positive)¹
- *Acinetobacter* species (Gram-negative)¹
- *Pseudomonas aeruginosa* (Gram-negative)²
- *Candida* species (fungi)²
- *Corynebacterium diphtheriae* (Gram-positive)³

Genitalia

- *Corynebacterium* species (Gram-positive)¹
- *Lactobacillus* species (Gram-positive)¹
- Alpha-hemolytic and non-hemolytic streptococci
(Gram-positive)¹
- *Non-pathogenic Neisseria* species
(Gram-negative)¹
- *Candida albicans* (fungi)¹

Intestinal Tract

- *Escherichia coli* (Gram-negative)³
- *Proteus* species (Gram-negative)²
- *Enterococci* (Gram-positive)¹
- *Klebsiella* (Gram-negative)²
- Alpha-hemolytic and nonhemolytic *streptococci*
(Gram-positive)¹
- *Candida* species (Fungi)³
- *Clostridium* species (Gram-positive)³
- *Enterobacteriaceae* (Gram-negative)²
- *Pseudomonas aeruginosa* (Gram-negative)³

Potential Environmental Sources of Bacteria

- *Pseudomonads* (Gram-negative)—
soil, water, plants, and animals¹
 - *Pseudomonas* thrives in moist environments—
special attention should be paid to sink, water
baths, showers, hot tubs, and other wet areas²
- *Acinetobacter* species (Gram-negative)—
soil and water¹
- *Serratia marcescens* (Gram-negative)—
soil and water²
- *Pasteurella* species (Gram-negative)—
cats and dogs¹
- *Mycobacteria* (Gram-positive)—
water and food²

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1. Brooks G, Carroll K, Butel J, Morse S. *Medical Microbiology, 24th ed.* New York, NY:McGraw Hill; 2007.
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3. Ponferrada L, Prowant B, Satalowich R. Peritoneal dialysis complications. In: Counts CS, ed. *Core Curriculum for Nephrology Nursing, 5th ed.* Pitman, NJ:American Nephrology Nurses' Association;2008:824-51.



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