Access Care and Complications Management Update

2012

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PERITONEAL DIALYSIS
Proven, Effective Therapy

Care of the Adult Patient on Peritoneal Dialysis

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Care of the Adult Patient on Peritoneal Dialysis

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

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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 review of the current medical literature, the recommendations of the International Society of 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. **This guide is not intended to be the practice of medicine, nor does it replace medical clinical judgment.**

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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CLINICAL PROCESS FOR OPTIMAL OUTCOMES

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 for collection of clinical data necessary for outcomes assessment.

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 judgement and to facilitate coordination of team activities.

KEY ACTIVITIES

Identifies major activities of the renal team that 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

Optimal timing for peritoneal catheter insertion should take place 2 weeks prior to use of the catheter. This is to ensure anchoring of the internal and external cuffs and healing of the exit site.[1]

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 location
  - Presence of colostomy, gastrostomy or ureterostomy
  - Use of adult diapers
- Evaluate for:
  - Abdominal wall for rash and evidence of infection
  - Pre-existing abdominal scars
  - Chronic intertrigo under abdominal skin folds
  - Abdominal wall hernias that require repair[2]

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).[3] 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, fat and skin folds, moist areas due to perspiration, pressure points from clothing or areas that cannot be sufficiently visualized during exit-site care[3]
  - Determine whether midabdominal, high abdominal or presternal location is most appropriate for individual patient (see fig. 4 and 5)
  - Mark exit-site location with indelible ink using stencils or actual catheter[3]
- 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 catheter with or without a swan neck bend (see fig. 1) [2, 3]
  - Choice of catheter type may be impacted by belt-line location and body habitus[3]

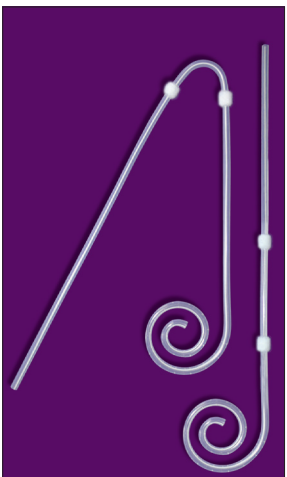
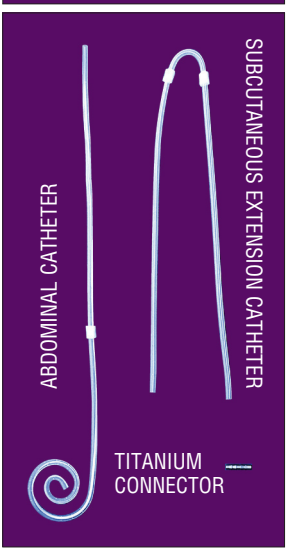


FIG. 1 Peritoneal dialysis catheters. Tenckhoff, two-cuff, straight intercuff segment, coiled-tip catheter (right) and Tenckhoff, two-cuff, preformed intercuff bend (swan neck), coiled-tip catheter (left). Extended catheter system (below).



Preoperative Management

- Patients with belt lines below the umbilicus may require a Tenckhoff style catheter that produces a laterally directed exit site above the belt (see fig. 2)[3]
- Patients with belt lines above the level of the umbilicus may require a catheter that is bent or manufactured with a preformed bend, so called swan neck design, that results in a downwardly directed exit site (see fig. 3)[3]

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 Catheter[2]

- 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
- Patient preference

Contraindications for Presternal/Upper Abdominal Peritoneal Dialysis Catheter

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

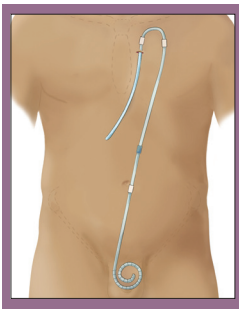


FIG. 4
An extended catheter with an upper chest exit site can be utilized in patients with morbid obesity, abdominal stomas or urinary-fecal incontinence or per patient preference.[2]

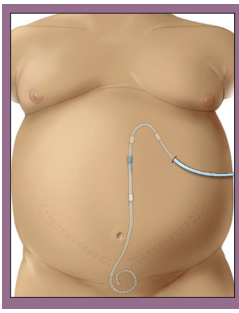


FIG. 5
An extended catheter for upper abdominal exit site may be useful for patients with obesity or floppy skin folds or per patient preference.[2]

Illustrations courtesy of John Crabtree, MD

Preoperative Management

- 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 technique) (see figs. 6A and 6B)[4]
- Catheter embedding procedure can be performed with any catheter type, i.e., upper abdominal catheter and presternal catheter [3]

Advantages of Embedded Peritoneal Dialysis Catheter[3]

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

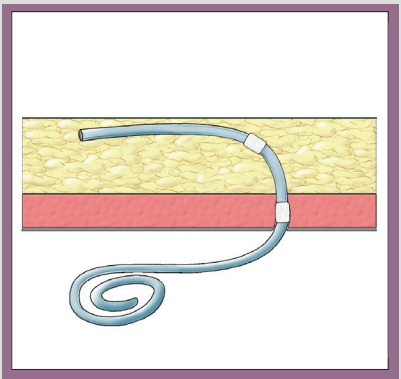


FIG. 6A

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

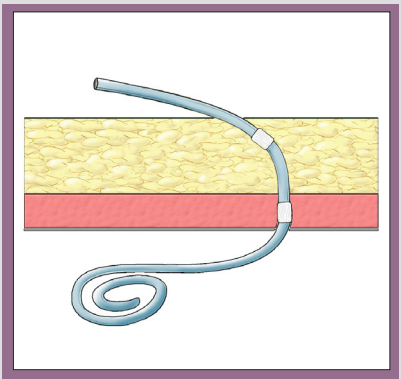


FIG. 6B

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

Illustrations courtesy of John Crabtree, MD

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, 2]
- Bowel preparation in case of previous history of constipation (e.g. mineral oil, enema, or a stimulant suppository is administered on the evening before surgery to evacuate the lower colon) [1, 2]
  - Avoid using sodium phosphate bowel preps [5]
- Shower or bathe with disinfectant soap on the day of surgery [1, 2]

Postoperative:

- Keep sterile dressing clean, dry, securely taped for one week unless there is excess drainage or bleeding [1]
- 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 or baths until completely healed up to two weeks except in case of buried catheter (after one week of surgery) [3, 4]

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, 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, the nephrologist at the bedside or interventionalist at an access center.[1]

KEY ASSESSMENTS

- Verify completion of preoperative activities:
  - Fasting state maintained
  - Shower on day of surgery with antibacterial soap [1, 2]
  - Bladder emptied or Foley catheter as needed [1, 2]
  - Bowel preparation complete [1, 2]
- Verify exit site marked appropriately

KEY ACTIVITIES

Prepare patient:

- Administer antistaphylococcal antibiotic preoperatively [6]
  - First-generation cephalosporin 1000 mg intravenously, 1 to 3 hours preoperatively

OR

  - Vancomycin 1000 mg intravenously, administered approximately 12 hours preoperatively [7*]
  - A prospective randomized trial determined that vancomycin was superior to cephalosporin or no treatment in reducing post-operative peritonitis [7*]
  - If vancomycin is used, weigh potential benefits versus risk of resistant organisms**
- Perform surgical skin prep (use electric clipper to avoid skin nicks) [2]

Prepare catheter:

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

*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 pre-operative antibiotics

Perioperative and Intraoperative Management

Insert catheter:

Several methods of catheter implantation have been developed including open dissection, simple laparoscopic, modified advanced laparoscopic, blind techniques, ultrasound or flouroscopically assisted percutaneous techniques. 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 preferred.[6] Curled compared with straight intraperitoneal segment associated with less infusion pain [8]
- Paramedian insertion with deep cuff resting within the muscle (see fig. 7)[1]

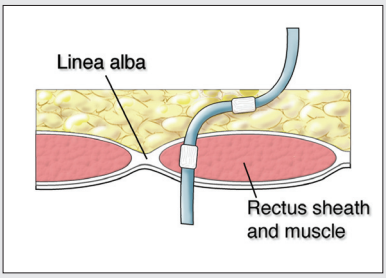
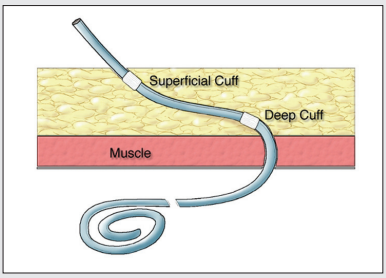


FIG. 7

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

- Position deep cuff in rectus sheath of abdominal wall)[1]
- Implanting the cuff superficial to the rectus fascia can lead to the formation of a hernia or pseudohernia and late pericatheter leak (see fig. 8)[1]



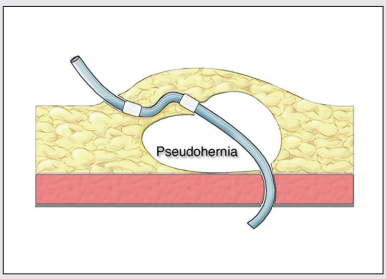


FIG. 8

(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 tract may dilate and develop a true hernia.

Illustrations courtesy of John Crabtree, MD

Perioperative and Intraoperative Management

- Catheter tip should have deep pelvic location[1]
- Close peritoneum below level of deep cuff with purse-string absorbable sutures[1]
- Position subcutaneous cuff no closer than 2 cm from exit site[1, 6]
  - Sinus tract is too long (>2-3 cm)—the epithelium will not reach the cuff and granulation tissue may develop deeper in the tract. As a result, may see drainage or serous weeping
  - Sinus tract is too short (< 2 cm)—the epidermis may be irritated by the cuff resulting in redness and irritation with eventual cuff extrusion[3]
- Subcutaneous tunneling instruments should not exceed the diameter of the dialysis catheter
- Straight catheters should not be sharply arched as the catheter has memory
- Sharply arching a straight catheter may encourage migration and cuff extrusion (see figs. 9–10)[2]

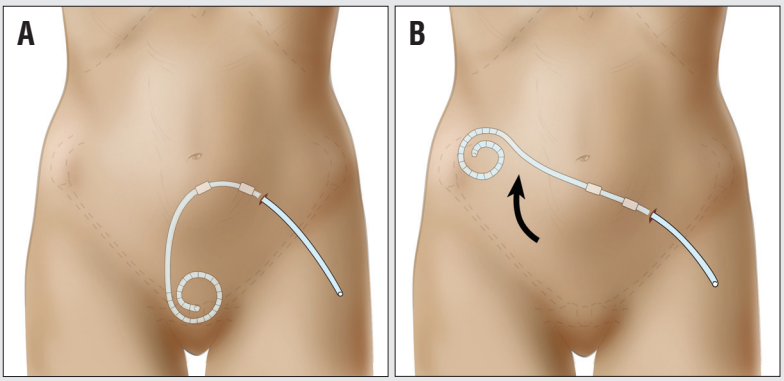


FIG. 9
(A) Straight catheter implanted into arcuate configuration.
(B) Shape memory can cause catheter tip migration out of the pelvis.

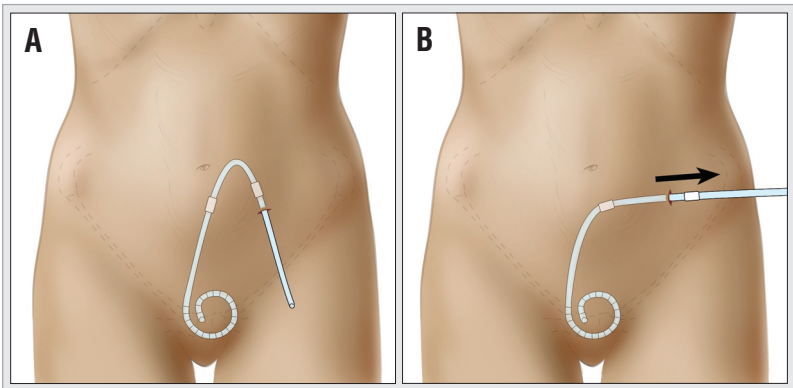


FIG. 10
(A) Straight catheter implanted into arcuate configuration.
(B) Shape memory can cause the superficial catheter cuff to extrude through the exit site.

Illustrations courtesy of John Crabtree, MD

- Position exit site downward or lateral[1, 6]
- Create the smallest skin hole possible to provide for catheter exit site[6]
- Immobilze catheter with medical adhesive tincture (if available) and sterile adhesive strips[3]
- Do not utilize catheter anchoring sutures at the exit site due to risk of infection[6]
- 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[1]
- Catheter position should be revised until satisfactory flow function is achieved before procedure end
- A trial irrigation of the catheter is performed to identify potential problems with flow. With the patient in reverse Trendelenburg position, infuse a standard one-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 drawn into catheter tip and side holes toward the end of the drainage phase
- With nonlaparoscopic 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 tract and exit-site trauma in the event that catheter repositioning is required.

Final catheter preparation:

- Place 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 absorbent dressing and tape securely[1, 9]
- Tape catheter securely to abdomen in several places
- Transparent occlusive dressings alone are not recommended[1, 9]

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 tract including immobilization of the catheter to prevent trauma to the exit site and cuffs, and minimizing exposure to bacteria and prevent colonization.[9] 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
  - Infection[1]
  - Gross contamination
  - Wetness
- Maintain clean, dry, intact dressings[1]
- Utilize aseptic technique using mask and gloves[1]
- Exit-site care:
  - Minimize manipulation of catheter
  - Use aseptic technique, including masking and wearing sterile gloves for postoperative dressing changes until healed[9]
  - Inspect and classify exit site[1, 10]
  - Palpate tunnel
  - Clean with nonirritating solution (i.e., nonionic surfactant, normal saline, or chlorhexidine)[1, 6]
  - Protect sinus tract and wound from povidone iodine and hydrogen peroxide[1, 10]
  - Tape dressing securely[1]
  - Immobilize catheter[1]
- If the catheter is not used for a period of time, it is not necessary to check catheter patency and function
- Catheters that are exteriorized secondarily (Moncrief technique) can be used immediately for full-volume peritoneal dialysis.[4] 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[6, 9]
  - Avoid heavy lifting, stair climbing, straining and constipation until catheter 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)[9]
- 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 tract. Catheter survival of greater than 80% at one year is desired.[1, 2] 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 tract
- Classify exit-site appearance by checking for:[10]
  - 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 reviewing cycler 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:[6]

- 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
  - Note: Avoid mupirocin ointment with polyurethane catheters
- Mupirocin intranasal bid for 5 to 7 days every month if identified as nasal *Staphylococcus aureus* carrier

Chronic Care of Peritoneal Dialysis Catheter

PATIENT EDUCATION

Daily routine exit-site care:

- Wash and dry hands thoroughly[1, 9]
- Inspect catheter, exit site and tunnel before catheter care[1]
- Showers recommended; avoid immersion in tub
- Cleanse exit site every day, every other day or a minimum of two to three times per week[9]
- Cleanse exit site with liquid antibacterial soap or antiseptic (i.e. povidone iodine or chlorhexidine)[6]
- Cleansing agent should be nonirritating, nontoxic, antibacterial and in liquid form[1, 9]
- Do not transfer cleansing agent between containers to avoid cross-contamination[1, 9]
- Soften crusts and scabs with saline or soap and water. Never forcibly remove crusts and scabs[1, 9]
- Apply antibiotic cream or ointment for prophylaxis using a cotton swab. Do not apply directly from tube
- Avoid mupirocin ointment with polyurethane catheters[6]
- Immobilize catheter with tape or immobilization device at all times
- Apply dressing to protect from contamination
- Povidone iodine can be damaging to the peritoneal catheter over time
- Healed site may be left uncovered but should be kept dry
- In case of prophylactic antibiotics, a nonocclusive dressing may be suitable
- Perform exit-site care if exit site becomes wet or grossly contaminated[9]
- Report trauma of exit site or catheter
- Maintain regular soft bowel movements[6]

CARE FOR PATIENTS WHO SWIM [11]

- 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

section

2

Noninfectious Complications

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Noninfectious Complications

Pericatheter and Subcutaneous Leaks

Pericatheter and subcutaneous leaks are often related to poor catheter implantation technique, anatomical abnormalities, utilizing the catheter prior to healing or trauma.[12] Leakage occurring in the first 30 days following catheter implantation is usually external in nature and is evident at the catheter exit or incision site.[1] 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.

Delaying peritoneal dialysis for 14 days following catheter insertion is a useful preventative measure in order to avoid early leakage.[12] Attention to surgical recommendations on insertion location (paramedian approach) and positioning of internal cuff reduce the risk of leakage.

KEY ASSESSMENTS

Patients at risk:

- Patients with poor tissue healing (diabetics, elderly, malnourished, and those taking corticosteroids)
- Patients with increased intra-abdominal pressure[12]

Findings that require evaluation for leaks:[12]

- 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)

KEY ACTIVITIES

External leaks:

- Verify that clear fluid at incision or exit site contains glucose, using glucose test strip[20]
- 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 a dry day or suspension of PD to be considered
- These leaks increase the risk of peritonitis and consideration should be given to prophylactic antibiotic administration[11]

Noninfectious Complications

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 or magnetic resonance imaging (MRI) without gadolinium (see imaging techniques)[13, 14]
- Increase clinic visits as needed for observation

IMAGING TECHNIQUES

- CT peritoneography (see Appendix)[13]
- Abdominal fluoroscopy with contrast
- Peritoneal scintigraphy (see Appendix)[15]
- Peritoneal MRI with dialysate as "contrast medium"[14]

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.

Radiograph courtesy of Ali Abu-Alfa, MD

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

Noninfectious Complications

CLINICAL APPROACH TO LEAKS

Dialysis therapy:

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

In new patients in whom dialysis is not urgently required:

- Delay use of PD for up to 3 weeks if necessary until leakage subsides[12]
- Reinitiate PD in presence of trained staff to assess for recurrence

Invasive steps:

- Persistent leak may require surgical repair[12]
- 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 replacement[12]

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 following surgical correction
- 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/wound
- Condition of subcutaneous cuff and tunnel
- Type of leak
- Diagnostic testing and results
- Dialysis prescription alterations

Enter data into catheter management database

Noninfectious Complications

Peritoneal Catheter Obstruction

Inflow and outflow obstruction occur more commonly as early complications but can also occur at any time, especially during or following episodes of peritonitis.[1] Ascertaining the cause of obstruction will assist in determining the appropriate intervention.

KEY ASSESSMENTS

Inflow obstruction may be due to:[1]

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

Outflow obstruction may be due to:[1]

- 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]

- Eliminate kinks or remove clamps on transfer set, tubing and catheter. Examine portions hidden by clothing and dressings
- Change body position
- Dislodge blockage (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[1]
- Open surgical repositioning of catheter or replacement[1]
- Partial omentectomy or omentopexy[3]
- Adhesiolysis if indicated
- Fluoroscopically guided stiff wires or stylet manipulation[1]
- Fogarty catheter manipulation[1]

CLINICAL APPROACH TO CATHETER OBSTRUCTION

In case of fibrin-related obstruction:

- Add heparin 500 U/L to dialysate each exchange[1]
- Instill recombinant tissue plasminogen activator (tPA)[16]

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. Add antibiotics (first-generation cephalosporin preferred) to dialysate in following exchange.

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

Noninfectious Complications

Hernia

Significant abdominal wall hernias should be surgically repaired prior to the initiation of peritoneal dialysis. 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 incisional, umbilical and inguinal. Incisional hernias occur more often when the peritoneal catheter is placed through the midline instead of the paramedial approach through the rectus muscle.[1]

KEY ASSESSMENTS

- Protrusion at umbilicus, inguinal area, genitalia or incision
- Determine reducibility/pain/size
- Evaluate for tenderness and inflammation
- If incisional, review catheter placement procedure

KEY ACTIVITIES

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

THERAPEUTICS

- Significant hernia requires surgical repair[1]
- Hernias should be repaired with prosthetic mesh techniques to minimize the high risk of recurrence in patients on PD[3, 17, 18]
- 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[1]
- Provide HD backup if needed 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 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[1]
  - Initial low-volume intermittent dialysis[1]
  - Dry abdomen during ambulatory periods during first two weeks
  - Volume graduated incrementally over two 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

Noninfectious Complications

Abdominal Discomfort During Infusion and Drain

KEY ASSESSMENTS[19]

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:[19]

- 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 cycler to deliver modified tidal (85–90%)
- Ensure proper warming of dialysis solution
- Investigate PD catheter position — flat plate of abdomen
- Reposition PD catheter if unresolved as necessary
- Check shelf life of used dialysis solution
- **For patients with significant discomfort:** Manual addition of bicarbonate or xylocaine solution to dialysis solutions has been documented.[11] Prior to adding any medication to dialysis solutions, be sure to confirm compatibility of the medication with the specific PD solution.

For abdominal discomfort during outflow:

- Leave small amount of dialysate fluid in the peritoneal cavity in patients on CAPD. In APD patients, program cycler to deliver modified tidal PD (85-90%)[19]

PATIENT EDUCATION

Teach patient causes and interventions:[19]

- 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
- Peritonitis prevention
- Medication administration
- Training for APD

OUTCOMES EVALUATION

Collect data to include:[19]

- Duration and degree of discomfort
- Interventions
- Adjustments to dialysis prescription
- Patient tolerance
- Medications prescribed
- Diagnostic tests and results
- Enter data into catheter management database

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.

KEY ASSESSMENTS

- Evaluate degree and duration of shoulder pain
- Interview patient regarding recent infusion of air during exchange procedure[20]
- Rule out pain of cardiac origin
- Assess for bowel perforation[20]

KEY ACTIVITIES

- Send effluent sample for cell count and culture to rule out potential contamination
- Prime PD system according to manufacturer's instructions[20]
- 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 subdiaphragmatic free air in the peritoneal cavity[20]
- Intervention: infuse full exchange volume, then drain dialysate with patient in knee-chest or Trendelenburg position[20]

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

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.[21, 22]
Mild bleeding can be caused by catheter-induced trauma, strenuous exercise and the formation of abdominal adhesions. Any bleeding, however, needs to be carefully monitored for severity and potential serious causation.[21 22]

KEY ASSESSMENTS

- Observe dialysis exchange drain fluid for color and clarity
  - Rule out peritonitis
- Obtain patient history, investigate potential causes including;[21 22]
  - Status post peritoneal catheter placement
  - Retrograde menstruation/ovulation in females (Note interval and length of occurrence)
  - Surgical causes such as cholecystitis, rupture of the spleen or pancreatitis
  - 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 sclerosis[21]
  - Recent enema, sigmoidoscopy, colonoscopy, episode of abdominal trauma or abdominal disease
  - Recent use of intraperitoneal tPA

KEY ACTIVITIES

CLINICAL APPROACH TO HEMOPERITONEUM

For postcatheter insertion blood-tinged effluent:

- 200–1500 mL volume flush with heparinized dialysis fluid or saline until drain is clear[1]
- Add heparin 500–1,000 U/L as long as the effluent has visible signs of blood or fibrin to maintain catheter patency[21]
- Intraperitoneal instillation of heparin does not affect systemic coagulation parameters and does not increase the risk of bleeding.[21] 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. Hence, IP heparin is contraindicated in patients with heparin-induced thrombocytopenia (HIT)[23]
- Observe drain fluid color with dialysis exchanges
- Document duration of blood-tinged exchanges and progression (increase/decrease)
- Check hematocrit (serum and dialysis) as needed
- Consider investigating for peritonitis or other acute abdominal issue if prolonged

Noninfectious Complications

Other causation:[21]

- Add heparin 500-1,000 U/L as long as the effluent has visible signs of blood or fibrin to maintain catheter patency
- Perform rapid exchanges with dialysate at room temperature until effluent clears
- Obtain imaging and surgical consultation as required

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

Noninfectious Complications

Hydrothorax

Hydrothorax secondary to a pleuroperitoneal communication is an uncommon complication of peritoneal dialysis. The management of hydrothorax should begin with the temporary discontinuation of peritoneal dialysis to avoid aggravating pleural fluid accumulation and allowing the effusion to regress.[24]

KEY ASSESSMENTS

Signs and symptoms of pleural effusion:[21]

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

KEY ACTIVITIES

Diagnostic:[21]

- 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
- Isotope scanning to identify pleural-peritoneal communication
- High glucose, low protein, pleural fluid on thoracentesis

Radiograph courtesy of John Crabtree, MD

Noninfectious Complications

CLINICAL APPROACH TO HYDROTHORAX

- Conservative management for pleural leakage in the form of peritoneal rest and intermittent low volume dialysis is rarely successful[24]
- Temporary hemodialysis for 2–6 weeks usually required to allow pleuroperitoneal communication to seal, especially following surgical interventions[24]
- Thoracentesis or chest tube drainage with chemical pleurodesis (talc slurry, autologous blood, OK-432 (Picibanil), minocycline) has been successful[24]
- Video-assisted thorascopic surgery (VATS) may permit visualization of a pleuroperitoneal communication and direct surgical obliteration if appropriate[24]
- Thoracoscopic pleurodesis with talc poudrage and/or mechanical rub produces 87–93% success rate in resolving pleural leaks[25]
- Follow-up radiograph to establish closure of pleuroperitoneal communication may be utilized before restarting PD[25]

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:

- Type of leak
- Diagnostic testing and results
- Interventions
- Response to interventions

Enter data into catheter management database

Noninfectious Complications

Catheter Adapter Disconnect or Fracture of Peritoneal Catheter

KEY ASSESSMENTS

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

KEY ACTIVITIES

- Initiate prophylactic antibiotics[26]

For adapter disconnect or catheter fracture:[26]

- 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[26]

PATIENT EDUCATION

Instruct patient to:[26]

- 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:[26]

- 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 hemastat 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

Noninfectious Complications

notes:

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.

Baxter

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 minimum of 1 in 18 patient months. Rates of 1 in 41–52 months have been reported in some centers. The center's overall peritonitis rate should be monitored at a minimum on an annual basis.[27]

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:

- The following three criteria alone or in combination may be indicative of the presence of peritonitis:[6]
  - Abdominal pain
  - Cloudy effluent with WBC >100/µL of which at least 50% are polymorphonuclear neutrophils (PMN)
  - If absolute cell count is less than 100/µL with a predominance of PMNs, the diagnosis of peritonitis is probable
  - Identification of organisms on Gram stain or culture

Differential Diagnosis of Cloudy Effluent:[6, 28]

- Culture-positive infectious peritonitis
- Infectious peritonitis with sterile cultures
  - Faulty culture techniques
  - Inadequate specimen
  - Inadequate culture conditions
  - Prior antibiotic usage
  - Slow-growing organisms
- Noninfectious causes of cloudy effluent (see Appendix)
- Specimen taken from "dry" abdomen

KEY ACTIVITIES

Initiate the following:

Performed by the patient or 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 one to two hours.
   - Obtain specimen and inject 5-10 mLs into each blood culture bottle. Send 50 mL of peritoneal effluent to be centrifuged at 3000g for 15 min. followed by resuspension of the sediment for innoculation. For full detail on specimen handling (see Appendix)[27]

Infectious Complications: Peritonitis Management

3. In presence of cloudy effluent with pain and/or fever:
   - Initiate empiric antibiotic therapy within one hour while waiting for test results
4. In presence of cloudy effluent, add heparin 500 U/L to new bag until effluent clears (usually 48 to 72 hours)[27]
5. Initiate adequate pain management intervention. Peritonitis-related pain may require opiates for adequate control which should be prescribed in adequate amounts to control pain appropriately[8]
6. Assess for need for hospitalization[27]

- Discuss possibility of break in technique, compliance to hand washing, mask use
- Inquire about recent procedures, constipation, diarrhea, and antibiotic use
- Review peritonitis and exit-site infection history and treatment
- Review use of exit-site prophylaxis

PATIENT EDUCATION

- Immediately report cloudy effluent, abdominal pain and/or fever to PD unit[6]
- Save drained cloudy dialysate and bring to clinic
- Stress importance of obtaining specimen prior to beginning antibiotics

Patients previously educated on antibiotic administration should begin the following:

- Add intraperitoneal antibiotics for duration of required therapy
- Add heparin 500 U/L to each bag until clear[6]
- Report persistent cloudiness to PD unit
- Schedule retraining for technique issues

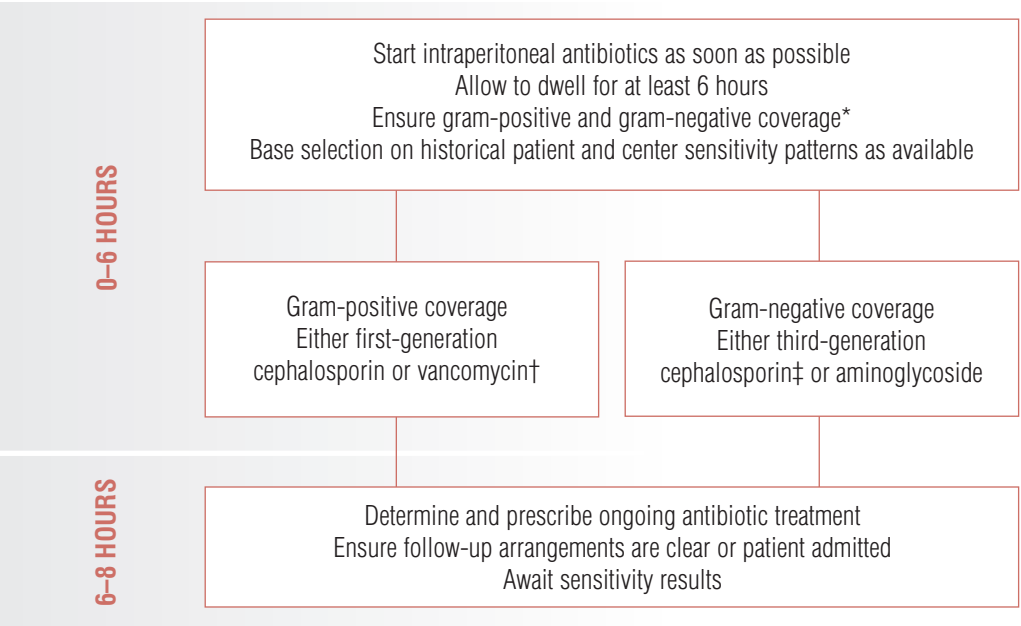
OUTCOMES EVALUATION

Collect data to include:

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

Enter data into catheter management database

Infectious Complications: Peritonitis Management



*Continued assessment and modification of therapy based on culture and sensitivity results; refer to subsequent sections for specific organisms cultured. Dwell time of the exchange for intermittent therapy must be a minimum of 6 hours.
†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.
‡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.

Infectious Complications: Peritonitis Management

Staphyloccocus aureus Peritonitis[27]

Staphylococcus aureus* on Culture

STEP 1

Continue gram-positive coverage based on sensitivities*
Stop gram-negative coverage, assess exit site again

If methicillin resistant, adjust coverage to vancomycin
Add rifampin 600 mg/day orally (in single or split dose) for 5–7 days (450 mg/day if BW <50 kg)

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

STEP 2

Clinical improvement
(symptoms resolve; bags clear):
- Continue antibiotics;
- Reevaluate for exit-site or occult tunnel infection, intra-abdominal abscess, catheter colonization, *etc.*

No clinical improvement
(symptoms persist; effluent remains cloudy):
- Reculture & evaluate‡

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

STEP 3

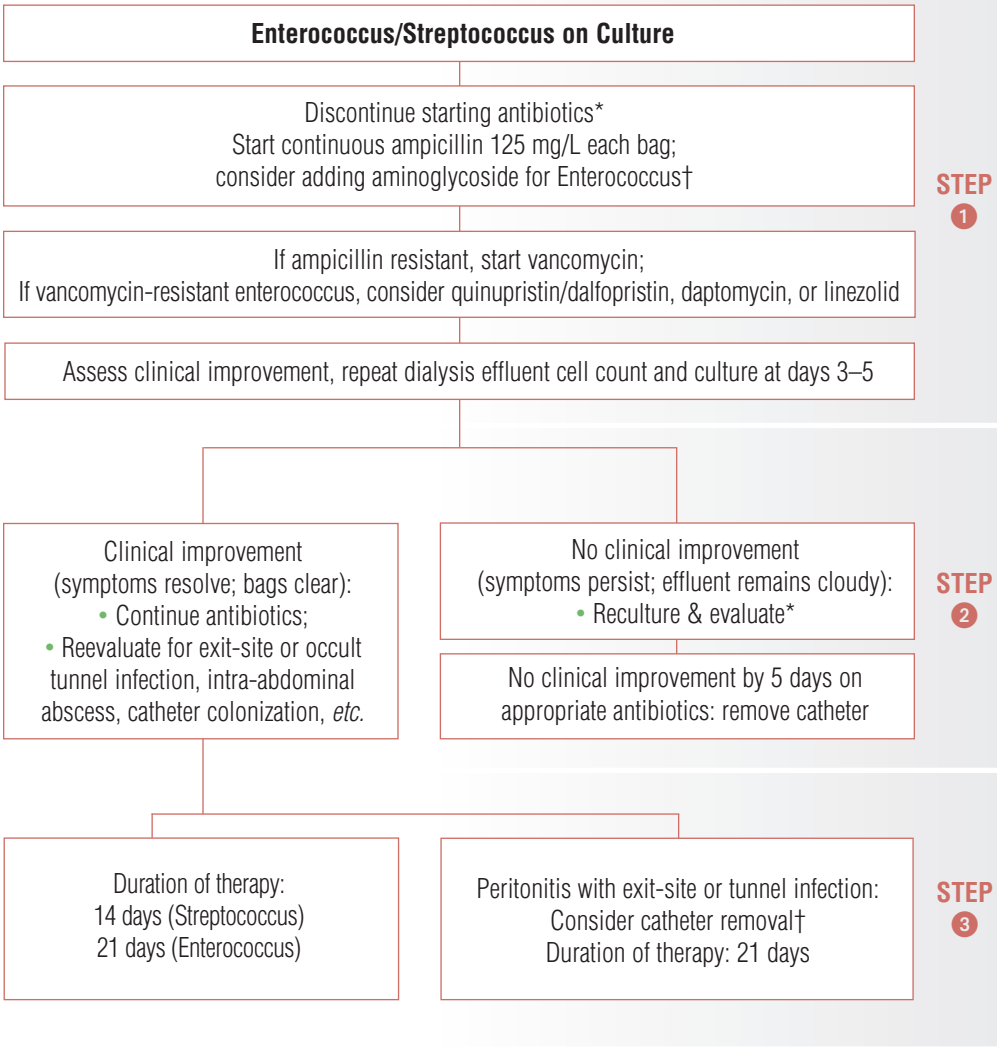
Duration of therapy:
at least 21 days

Peritonitis with exit-site or tunnel infection may prove to be refractory§ and catheter removal should be seriously considered.
Allow a minimum rest period of 3 weeks before reinitiating PD¶

*If vancomycin-resistant *S. aureus*, linezolid, daptomycin, or quinupristin/dalfopristin should be used.
‡In areas where tuberculosis is endemic, rifampicin use for treatment of *S. aureus* should be restricted.
§"Refractory" is defined as failure to respond to appropriate antibiotics within 5 days.
¶The duration of antibiotic therapy following catheter removal and timing of resumption of peritoneal dialysis may be modified depending on clinical course.
BW = body weight; PD = peritoneal dialysis.

Infectious Complications: Peritonitis Management

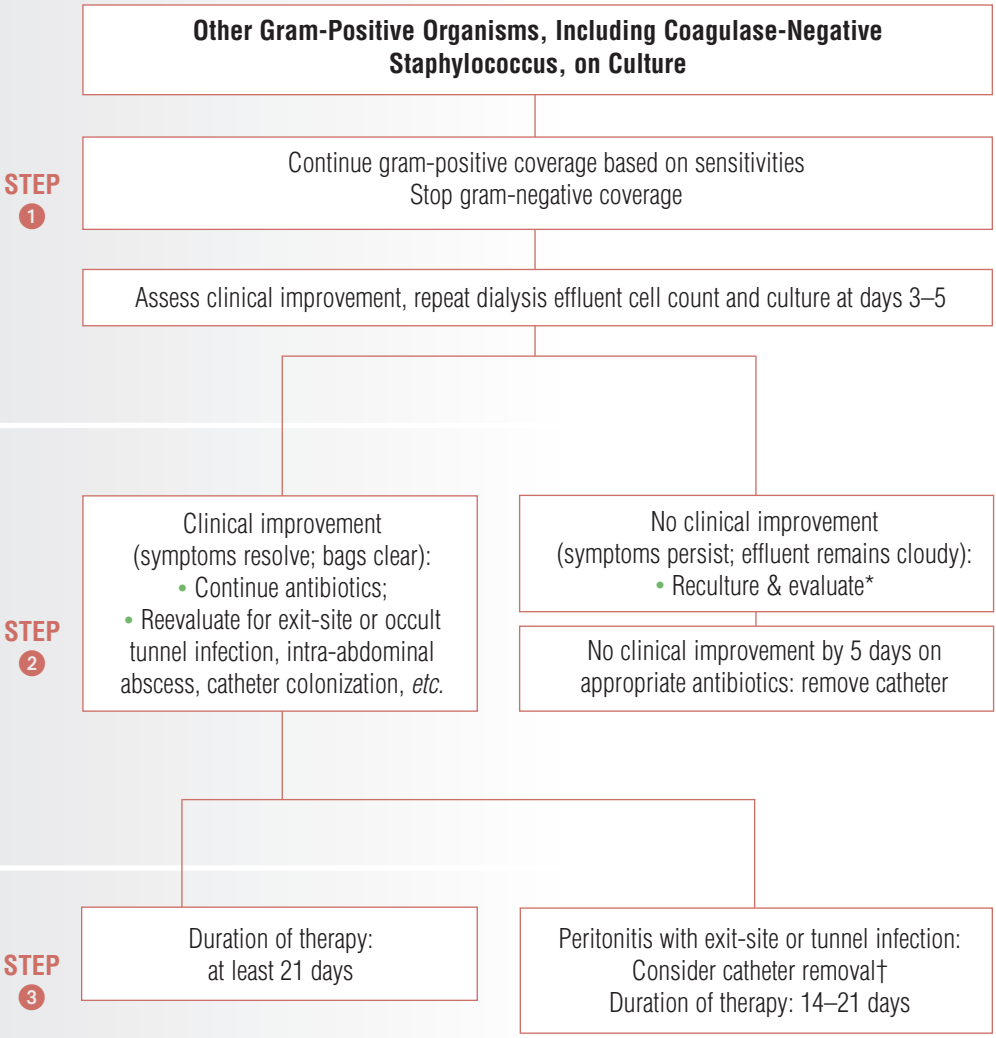
Enterococcus/Streptococcus Peritonitis[27]



*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.
†The manufacturer's precaution label states that these antibiotics should not be mixed together in the same solution container. Physicians' own judgment is necessary.
‡The duration of antibiotic therapy following catheter removal and timing of resumption of peritoneal dialysis may be modified, depending on clinical course.

Infectious Complications: Peritonitis Management

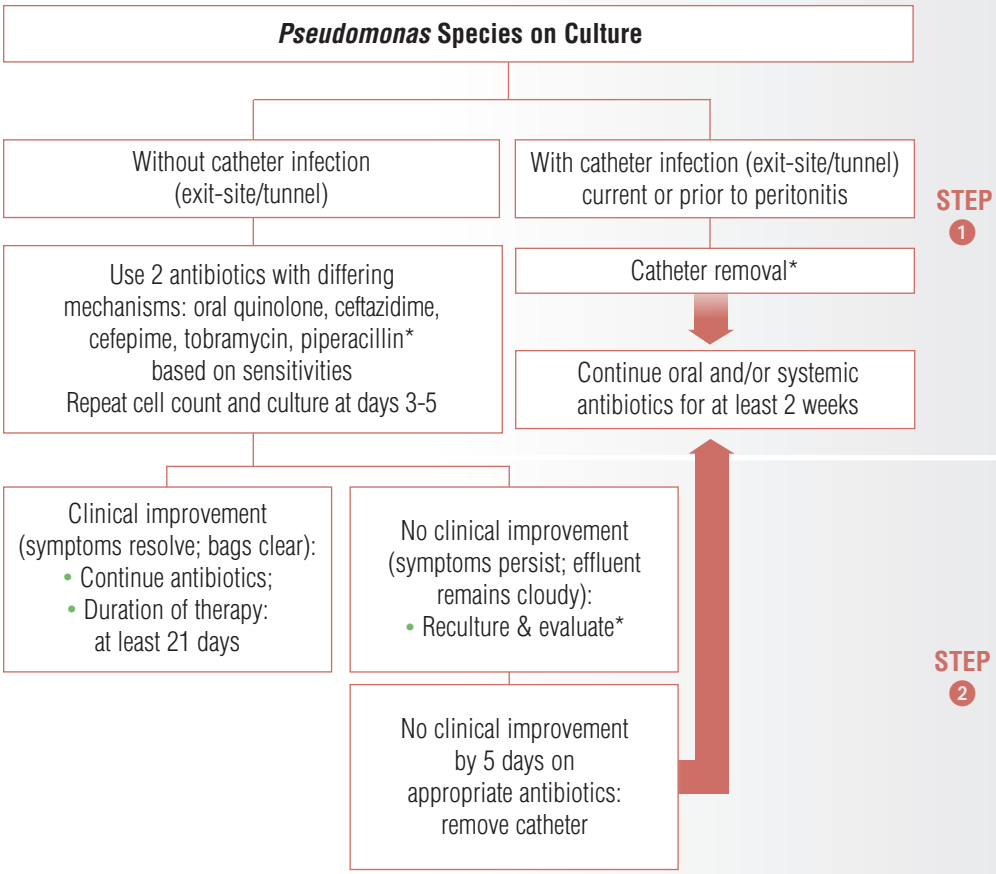
Other Single Gram-Positive Organism Peritonitis[27]



*CoNS can sometimes lead to relapsing peritonitis, presumably due to biofilm involvement.
†The duration of antibiotic therapy following catheter removal and timing of resumption of peritoneal dialysis may be modified depending on clinical course.

Infectious Complications: Peritonitis Management

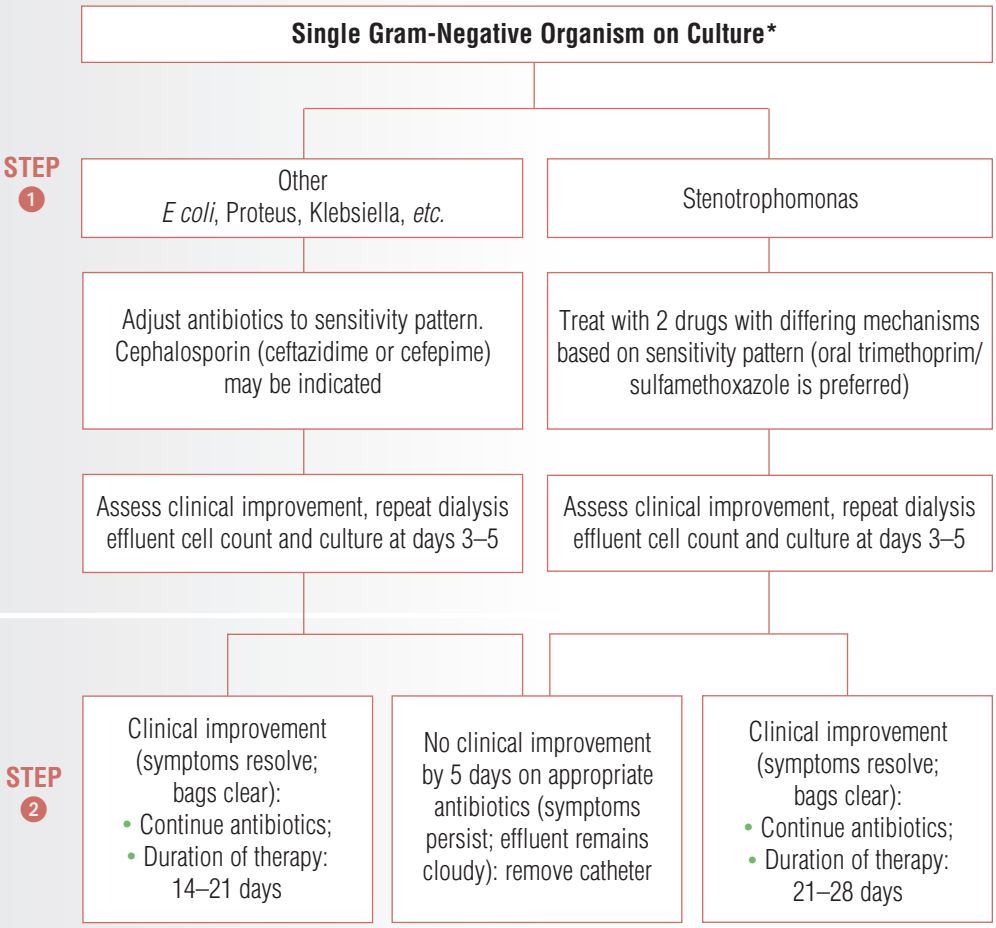
Pseudomonas aeruginosa Peritonitis[27]



*The duration of antibiotic therapy following catheter removal and timing or resumption of peritoneal dialysis may be modified depending on clinical course.

Infectious Complications: Peritonitis Management

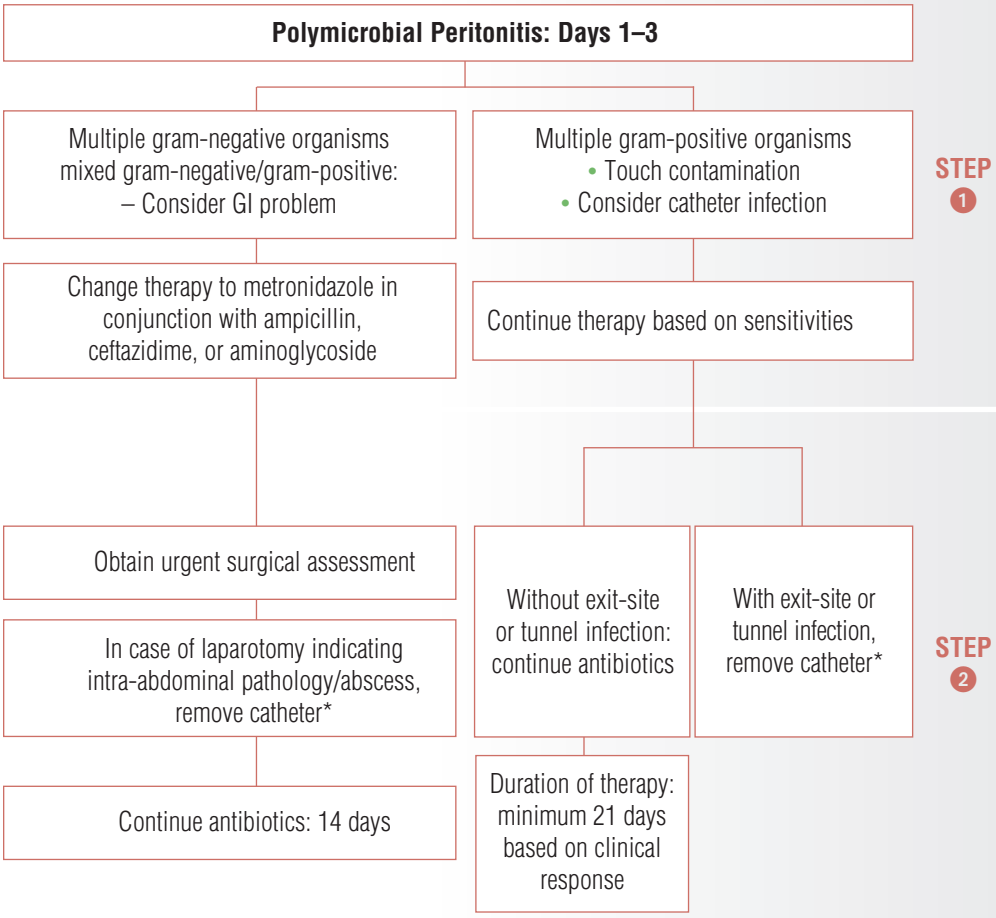
Other Single Gram-Negative Organism Peritonitis[27]



*Choice of therapy should always be guided by sensitivity patterns.

Infectious Complications: Peritonitis Management

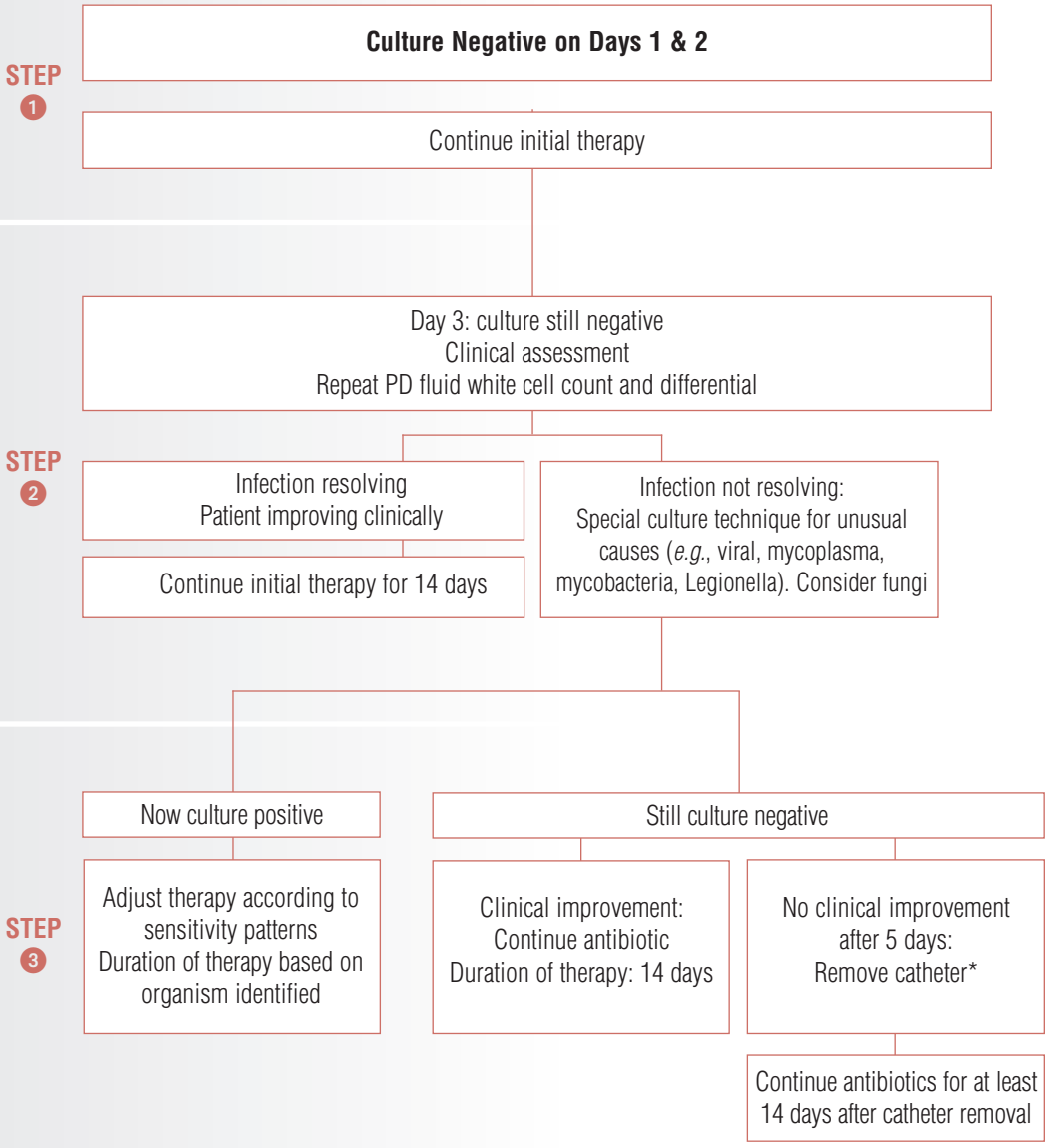
Polymicrobial Peritonitis[27]



*The duration of antibiotic therapy following catheter removal and timing or resumption of peritoneal dialysis may be modified depending on clinical course.
GI = gastrointestinal.

Infectious Complications: Peritonitis Management

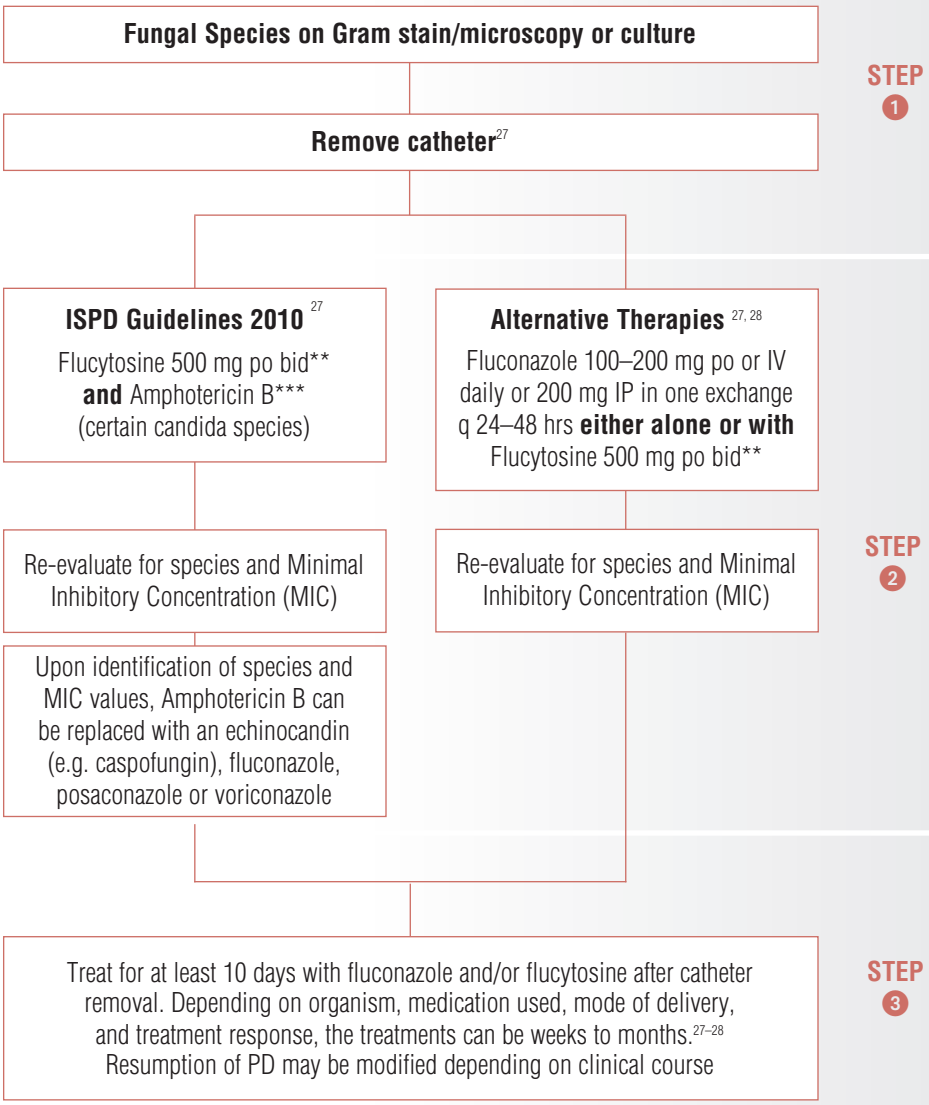
Culture-Negative Peritonitis[27]



*The duration of antibiotic therapy following catheter removal and timing or resumption of peritoneal dialysis (PD) may be modified depending on clinical course.

Infectious Complications: Peritonitis Management

Fungal Peritonitis*



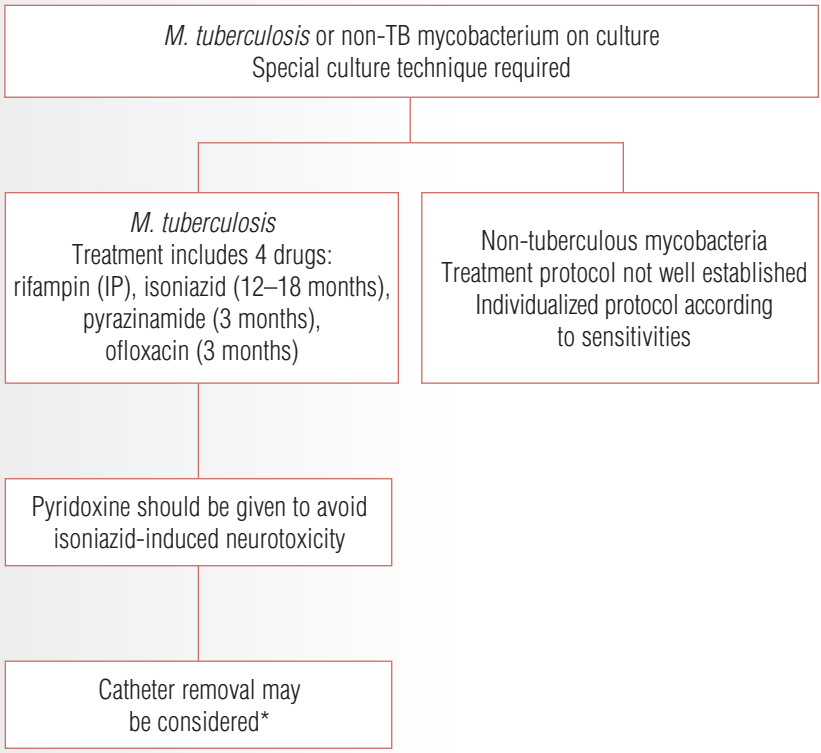
Note: IP use of Amphotericin B can cause pain and chemical peritonitis. IV use leads to poor peritoneal penetration.[27, 28, 29] Centers may prefer to reserve Amphotericin B for selected patients including those who are immunosuppressed, are refractory, or have had significant prior exposure to azoles.[30]

* Fungal peritonitis is typically preceded by courses of antibiotics.

** Monitor serum concentration levels regularly to avoid bone marrow toxicity and hepatotoxicity. Flucytosine PO may not be available in all regions. Risk of flucytosine resistance is high when used alone .

Infectious Complications: Peritonitis Management

Mycobacterium Peritonitis[27]

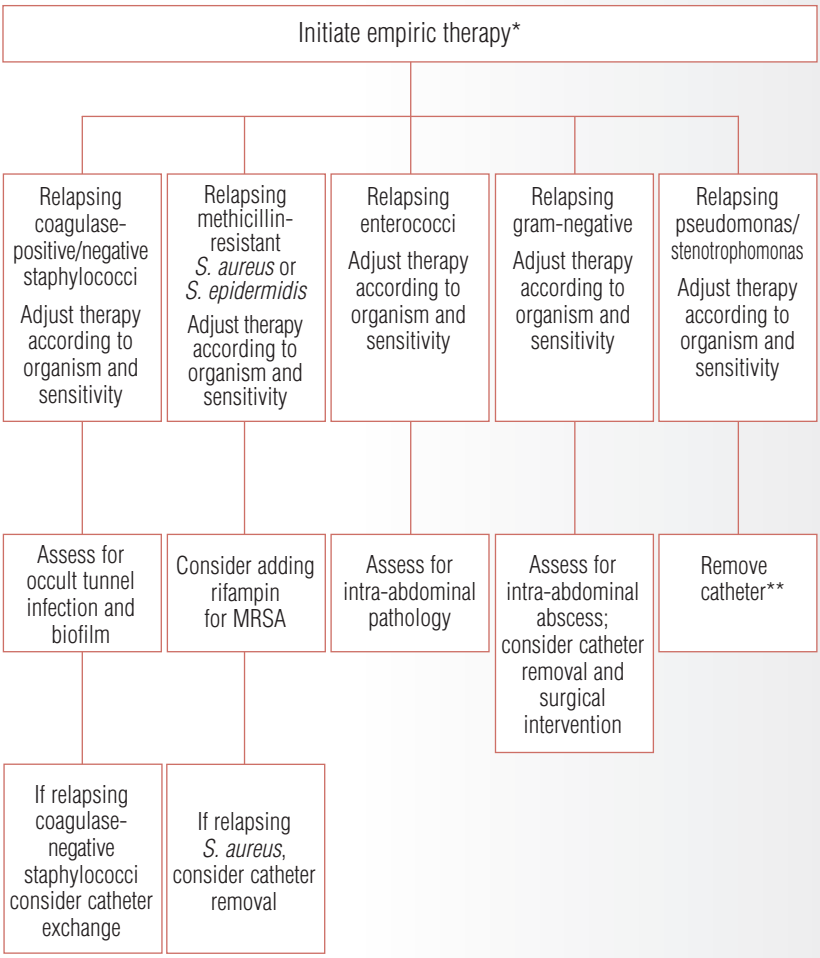


* The duration of antibiotic therapy following catheter removal and timing of resumption of PD may be modified depending on clinical course.

Infectious Complications: Peritonitis Management

Relapsing Peritonitis[6]

Relapse is defined as another episode of peritonitis caused by the same genus and species that caused the immediately preceding episode, occurring within four weeks of completion of the antibiotic course.



If no clinical response after 96 hours, consider removal of catheter. Reinsertion should be individualized based on HD option, presence of intra-abdominal abscess, exit-site or tunnel infections, patient and physician preferences. If clinical improvement is followed by additional relapse, catheter removal and replacement is recommended.

* Refer to Empiric Therapy.

** The duration of antibiotic therapy following catheter removal and timing of resumption of PD may be modified depending on clinical course.

Infectious Complications: Peritonitis Management

Peritonitis Terminology[27]

Recurrent Peritonitis

Defined as an episode of peritonitis that occurs within 4 weeks of completion of treatment for a preceding episode but with a different organism

Relapsing Peritonitis

Defined as an episode of peritonitis caused by the same genus and species of bacteria that caused the immediately preceding episode or 1 sterile episode and occurring within four weeks of completion of antibiotics (see previous page)

Repeat Peritonitis

Defined as an episode of peritonitis that occurs more than 4 weeks after completion of antibiotics for an infection with the same organism

Refractory Peritonitis

Defined as failure to observe clearing of the effluent 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 peritonitis episodes should not be counted as another peritonitis episode when determining the peritonitis rate.
- Recurrent and repeat peritonitis episodes should be counted when determining the peritonitis rate.

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."[27]

KEY ASSESSMENTS[27]

- Purulent discharge from exit site, spontaneous or expressed from tunnel, cuff or sinus
- Persistant erythema may be precursor to purulent drainage
- Pain or tenderness at exit site or over the tunnel
- If exit site is reddened, without drainage and culture positive, may indicate colonization
- Erythema or skin reaction may be noted following catheter implantation or trauma
- *Staphylococcus aureus* carrier status/use of prophylaxis
- Compliance with prophylaxis
- Precipitating or contributing conditions (break in technique, gross contamination, etc.)
- Suboptimal exit-site care

KEY ACTIVITIES

Initiate the following:[6]

- 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 appearance
  - Empiric therapy should include *Staphylococcus aureus* coverage
  - In patients with history of pseudomonas ESI, empiric therapy should include targeted antibiotic therapy
- In the absence of purulence, tenderness or swelling, consider intensified local care (e.g. hypertonic saline soaks-see right)
- Monitor, classify and document condition of exit site, sinus and tunnel
- ESI due to SA and pseudomonas may be related to tunnel involvement
- If tunnel infection suspected, ultrasound of subcutaneous pathway may be helpful
- Increase frequency of exit-site care and dressing changes
- Retrain patient on appropriate exit-site care
- Schedule clinic visits to evaluate response to treatment plan

PATIENT EDUCATION

- Revise exit-site care
  - 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, one to two times per day[6]
- 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 preparation. Rifampin can induce drug metabolizing enzymes reducing levels of medications ie., anticonvulsants, warfarin and statins.

OUTCOMES EVALUATION

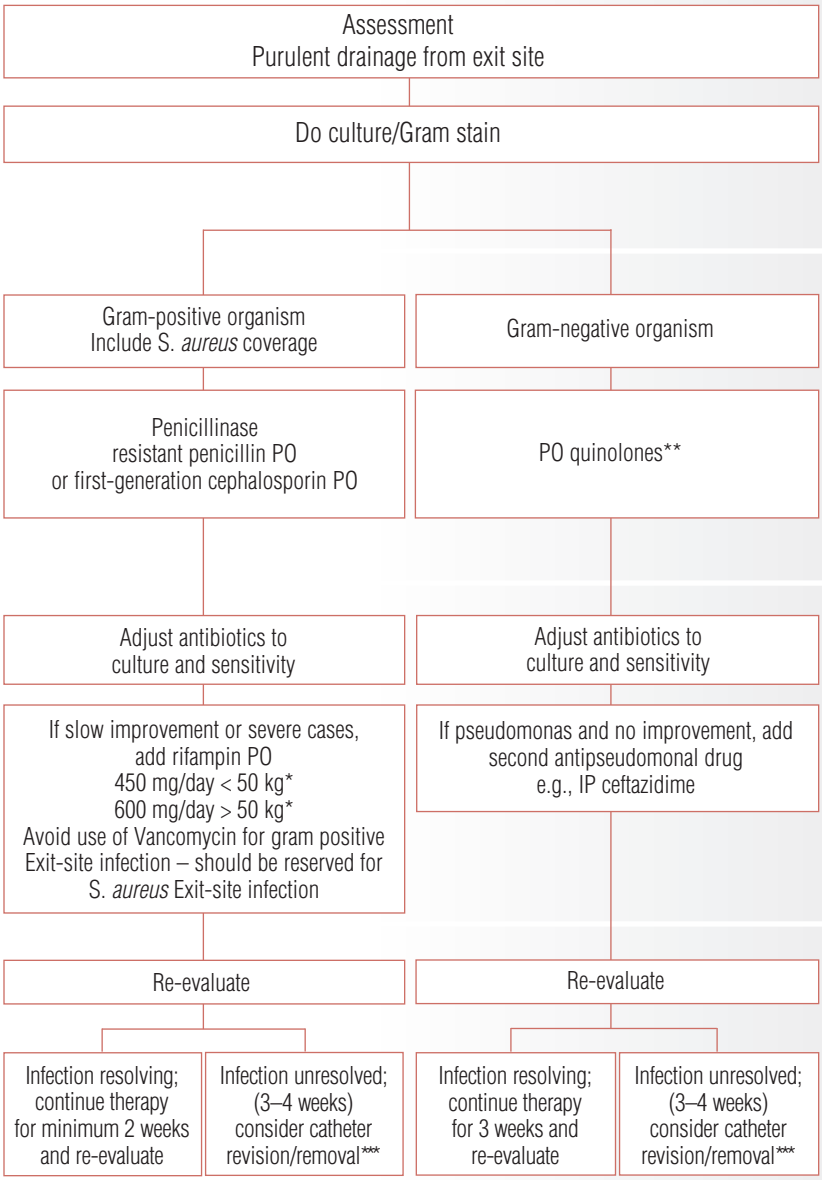
Collect data to include:

- Date of culture, organism identified, drug therapy used
- Date infection resolved
- Recurrent organisms, date of drug therapy
- Date of reeducation/training
- Antibiotic prophylaxis regimen used

Enter data into catheter management database

Infectious Complications: Management of Exit-Site/Tunnel Infection

Diagnosis and Management of Exit-Site/Tunnel Infection[27]



* In areas where tuberculosis is endemic, rifampin used for treatment of *Staphylococcus aureus* should be restricted. Rifampin can induce drug metabolizing enzymes reducing levels of medications ie anticonvulsants, warfarin and statins.

** 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 preparation.

*** The duration of antibiotic therapy following catheter removal and timing of resumption of PD may be modified depending on clinical course.

section

4

Antibiotic Dosing Guidelines

Baxter

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

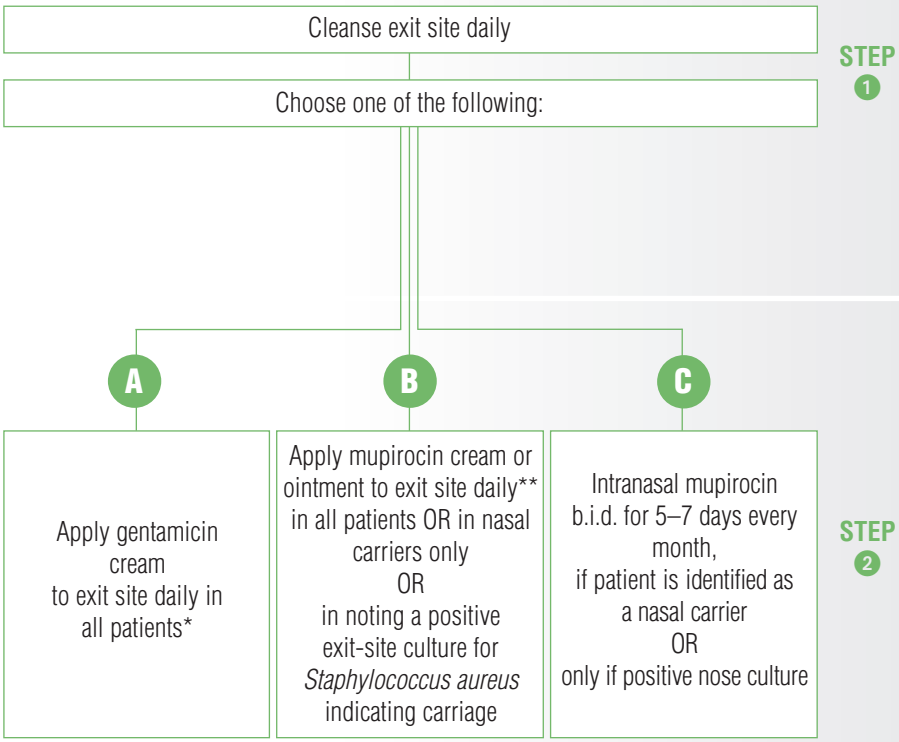
Oral Antibiotics Used in Exit-Site and Tunnel Infections[27]

Amoxicillin	250–500 mg b.i.d.
Cephalexin	500 mg b.i.d. to t.i.d.
Ciprofloxacin	250 mg b.i.d.
Clarithromycin	500 mg loading dose, then 250 mg b.i.d. or q.d.
Dicloxacillin	500 mg q.i.d.
Erythromycin	500 mg q.i.d.
Fluconazole	200 mg q.d. for 2 days then 100 mg q.d.
Flucytosine	0.5–1g q.d. titrated to the response and serum response levels (25-50 µg/mL)
Isoniazid	200–300 mg q.d.
Linezolid	400–600 mg b.i.d.
Metronidazole	400 mg t.i.d.
Moxifloxacin	400 mg q.d.
Ofloxacin	400 mg first day, then 200 mg q.d.
Pyrazinamide	25–35 mg/kg three times/week
Rifampin	450 mg q.d. for <50 kg, 600 mg q.d. for >50 kg
Trimethoprim/sulfamethoxazole	80/400 mg q.d.

mg= milligram; b.i.d.= two times per day; q.d.= every day; g= gram; p.o.= orally; kg= kilogram; t.i.d.= three times per day; q.i.d.= four times per day
Table used/adapted with permission, MultiMed, 2010

Antibiotic Dosing Guidelines: Exit-Site Prophylaxis

Exit-Site Antibiotic Prophylaxis[6]



* Gentamicin has been reported to be effective in reducing *Pseudomonas aeruginosa* as well.

** It has been reported that mupirocin ointment may cause structural damage to polyurethane catheters.

Antibiotic Dosing Guidelines: Peritonitis Management

Intraperitoneal Antibiotic Dosing Recommendations for CAPD Patients[27]

	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
Tobramycin	0.6 mg/kg	LD 8, MD 4
Cephalosporins		
Cefazolin	15 mg/kg	LD 500, MD 125
Cefepime	1000 mg	LD 500, MD 125
Ceftazidime	1000–1500 mg	LD 500, MD 125
Ceftizoxime	1000 mg	LD 250, MD 125
Penicillins		
Amoxicillin	ND	LD 250-500, MD 50
Ampicillin	ND	MD 125
Nafcillin	ND	MD 125
Oxacillin	ND	MD 125
Penicillin G	ND	LD 50,000 units, MD 25,000 units
Quinolones		
Ciprofloxacin	ND	LD 50, MD 25
Others		
Aztreonam	ND	LD 1000, MD 250
Daptomycin	ND	LD 100, MD 20
Linezolid	Oral 200-300 mg q day	
Vancomycin	15-30 mg/kg every 5–7 days	LD 1000, MD 25
Antifungals		
Amphotericin	NA	1.5
Fluconazole	200 mg	q 24–48 hrs
Combinations		
Ampicillin/sulbactam	2 g every 12 hours	LD 1000, MD 100
Imipenem/cilastatin	1 g b.i.d.	LD 250, MD 50
Quinupristin/dalfopristin	25 mg/L in alternate bags[a]	
Trimethoprim/ sulfamethoxazole	Oral 960 mg b.i.d.	

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%.

ND= no data
b.i.d.= two times per day
NA= not applicable
LD= loading dose, in mg
MD= maintenance dose, in mg

[a]Given in conjunction with 500 mg intravenous twice daily.

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Antibiotic Dosing Guidelines: Peritonitis Management

Intermittent Dosing of Antibiotics in Automated Peritoneal Dialysis (APD)[27]

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	Tobramycin
IP DOSE	Loading dose 1.5 mg/kg IP in long dwell, then 0.5 mg/kg IP each day in long day dwell

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
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section

5

Appendix

Baxter

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 patient 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 SEVEN 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

CT peritoneography and peritoneal scintigraphy are suggested when there is suspected dialysis fluid leakage in the abdominal wall, genital region, or pleural space. 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.[13, 15]

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:[13]

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:[15]

Procedure:

- Add 2 mCi of technetium-99m sulfur colloid to 2 L of dialysis solution
- Infuse radionucleotide-containing dialysate into supine patient with anterior dynamic images obtained at one 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

Principles of Accurate Peritoneal Dialysis Effluent Sampling and Culturing[27]

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)

Appendix

Peritoneal Effluent Culture Laboratory Processing[27]

The correct microbiological culturing of peritoneal effluent is of utmost importance to establish the microorganism responsible. 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 infection. Culture-negative peritonitis should not be greater than 20% of episodes. Standard culture technique is the use of blood-culture bottles, but culturing the sediment after centrifuging 50 mL of effluent is ideal for low culture-negative results.

Procedure:

- Centrifuge 50 mL of peritoneal effluent at 3000 g for 15 minutes
- Follow with resuspension of the sediment in 3–5 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

Peritonitis Rate Calculations[27]

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 months[27]

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 year[27]

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 rate
- Relapsing episodes of peritonitis are counted as a single episode of peritonitis
- Recurrent peritonitis is a new episode of peritonitis and should be counted as an individual occurrence
- Peritonitis rates should be no more than 1 episode every 18 months or 0.67 episodes per patient year per ISPD
- 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

Differential Diagnosis of Non-infectious Cloudy Effluent[28]

Cellular causes

1 Increased neutrophils

- Intra-abdominal pathology
  - Cholecystitis
  - Appendicitis
  - Bowel ischemia
  - Pancreatitis
  - Organ infarction
- Drug associated
  - Amphotericin B
  - Vancomycin
- Contamination of PD fluid
  - Endotoxin
  - Acetaldehyde
- Specimen from “dry” abdomen

2 Increased eosinophils

- 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 menstruation
- Ovulation
- Ovarian/hepatic cyst rupture
- Peritoneal adhesions
- Strenuous exercise
- Catheter-associated trauma
- Drug associated
  - Tissue plasminogen activator (tPA)

4 Increased malignant cells

- Lymphoma
- Peritoneal metastases

Appendix

Noncellular causes

5 Increased fibrin

- Post peritonitis
- Starting PD

6 Increased triglycerides

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

Appendix

Providing for a Safe Environment for Peritoneal Dialysis[20]

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:[20]

- 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

Appendix

Normal Bacterial Flora of the Human Body[31-33]

Nose, Mouth, & Upper Respiratory Tract

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

Skin

- *Staphylococcus aureus* (Gram-positive)
- *Staphylococcus epidermidis* (Gram-positive)
- *Acinetobacter* species (Gram-negative)
- *Pseudomonas aeruginosa* (Gram-negative)
- *Candida* species (Fungi)
- *Corynebacterium diphtheriae* (Gram-positive)

Genitalia

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

Intestinal Tract

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

Potential Environmental Sources of Bacteria

- *Pseudomonads* (Gram-negative)— *soil, water, plants, and animals*
  - *Pseudomonas* thrives in moist environments— special attention should be paid to sink, water baths, showers, hot tubs, and other wet areas.
- *Acinetobacter* species (Gram-negative)— soil and water
- *Serratia marcescens* (Gram-negative)— soil and water
- *Pasteurella* species(Gram-negative)— cats and dogs
- *Mycobacteria* (Gram-positive)— water and food

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