Antibiotics Tubes and Lines

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Abstract

Antibiotic prophylaxis in interventional radiology (IR) is widely used; however, such practice is based on data from the surgical literature. Although published guidelines can help determine the need for prophylactic antibiotic use in the patient undergoing percutaneous procedures, local practice patterns often dictate when such medications are given. In this article, the current state of periprocedural antibiotic use in commonly performed IR procedures (i.e., tube and catheter placements) is presented.

Keywords
- interventional radiology
- infection
- antibiotic
- prophylaxis

Antibiotic prophylaxis in interventional radiology (IR) is widely used to prevent puncture site infection, bloodstream inoculation, and infectious seeding of implanted foreign material or necrotic tissues after ablation or embolization.[1] Much of the standard practice for periprocedural antibiotic administration in IR has been influenced by published surgical literature, as the evidence supporting and describing optimal antibiotic use in IR remains limited.[2] Historically, the National Academy of Sciences/National Research Council surgical wound classification has been used to classify procedures for their associated risk of infections (►**Table 1**).[2,3] Administration of antibiotics is essential for contaminated and dirty procedures; however, in those circumstances, antibiotics are usually administered for therapeutic rather than preventative purposes.[4] The Joint Commission recommends administration of intravenous (IV) antibiotics within 1 hour of incision and a repeat dose administration if more than 2 hours have passed after the first dose.[5,6] Postprocedure antibiotic administration has not been shown to decrease the risk of infectious complications.[7] In patients with renal dysfunction, aminoglycosides should be avoided and repeat dose for most of the antibiotics (except ceftriaxone, clindamycin, and moxifloxacin) may require timing or dose adjustments.[8,9]

Although reduction in the risk of infection is an advantage of minimally invasive image-guided procedures, the risk can never be eliminated. Judicious use of antibiotics is essential to prevent development of antibiotic resistance. Appropriate use of existing guidelines and regular review of new evidence must be adopted. The first comprehensive review of periprocedural antibiotics in IR was undertaken by the Society of Interventional Radiology (SIR) in 2010,[10] and was updated in 2018.[1] These guidelines serve to provide recommendations derived from the most recent evidence for optimal prophylactic antibiotic administrations across all types of IR procedures in adult and pediatric patients. Additionally, the SIR guideline on mobile application[11] released in 2021 is a free, user-friendly resource for healthcare providers that provides patient-specific periprocedural antibiotics and anticoagulation requirements, by accounting for the patient's current medication and health status. These resources must be integrated into routine practice.

Tubes

Gastrointestinal

Gastrostomy/Gastrojejunostomy Tube

Percutaneous gastrostomy placement under fluoroscopy guidance was introduced in 1981 by Preshaw, a Canadian surgeon, as an alternative to percutaneous endoscopic gastrostomy.[12] "Pull-type" gastrostomy is an antegrade technique traversing the oropharynx, whereas "push-type" retrograde technique involves only percutaneous access through the abdominal wall. Risk of infectious complications after pull-type gastrostomies has been reported to be as high as 30% due to exposure to oral flora.[13] Retrospective data on push-type gastrostomies are limited and variable,[14–16] but recent prospective studies have demonstrated reduction in

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Table 1 Classification of interventional radiology procedures using the National Academy of Sciences/National Research Council Surgical Wound Classification

Classification	Definition	Infection risk (%)
Clean	No evidence of inflammation Performed under aseptic technique Without gastrointestinal (GI), genitourinary (GU), or respiratory tract access	<5
Clean contaminated	No evidence of inflammation Performed under aseptic technique With GI, biliary, GU, or respiratory tract access	5–10
Contaminated	Evidence of infection or inflammation without pus	~20[a]
Dirty	Infected biliary or GU systems, or the presence of an abscess	~39[a]

[a]Prophylactic antibiotics are essential.

peristomal infection rates with the use of prophylactic antibiotics. Ingraham et al reported no peristomal infections in patients treated with prophylactic antibiotics compared with 11.8 and 13.4% incidence (intention-to-treat and per-protocol analysis, respectively) in the placebo group.[17]

The 2018 SIR guidelines recommend prophylaxis for both push- and pull-type gastrostomy and gastrojejunostomy placement.[1] For push type, antibiotics against skin and mucosal organisms mainly *Staphylococcus aureus* and *Staphylococcus epidermidis* are needed. For pull type, additional coverage for oropharyngeal flora including *Streptococcus viridans*, *Lactobacillus*, non-diphtheroid *Corynebacterium*, and anaerobes like *Bacteroides* and *Actinobacillus* species is required.

Recommended Antibiotic Regimen

Push: The recommended regimen is 1 to 2 g cefazolin preprocedure.

Pull: The recommended regimen is 1 to 2 g cefazolin preprocedure followed by 500 mg cephalexin oral/gastrostomy-inserted twice daily for 5 days or 600 mg clindamycin IV at the time of procedure followed by 600 mg oral clindamycin twice daily for 5 days. Vancomycin or clindamycin–gentamycin is recommended for penicillin-allergic patients.

Percutaneous Cecostomy

Percutaneous cecostomy insertion, first described by Ponsky in 1986 for the treatment of Ogilvie's syndrome,[18] is commonly performed to manage fecal incontinence or refractory constipation in adult as well as pediatric patients.[19–22] Bowel preparation to decrease fecal load and risk of infection is performed before the procedure which includes liquid diet, laxatives, and prophylactic antibiotic agents. There is a risk of developing polymicrobial infections from anaerobes in colonic flora, *S. aureus*, and *S. epidermidis*. Although there is no consensus on first-choice prophylactic antibiotic for cecostomy, the following regimens are suggested based on existing literature.[1]

Recommended Antibiotic Regimens

1. Cefoxitin 30 mg/kg single prophylactic dose with addition of triple antibiotic regimen only in complicated insertions using gentamycin 2.5 mg/kg IV, metronidazole 10 mg/kg IV, and ampicillin 20 mg/kg IV administered before and for 2 days after procedure with continuation of metronidazole 10 mg/kg orally for a total of 5 days. This regimen is supported by a 15-year single-institution retrospective study of 290 cecostomies with occurrence of peritonitis in six patients (2%), one (0.3%) requiring abscess drainage and one (0.3%) death despite antibiotic treatment.[19]
2. Prophylactic gentamycin 2.5 mg/kg IV, metronidazole 10 mg/kg IV, and ampicillin 20 mg/kg IV administered before and for 2 days after procedure with continuation of metronidazole 10 mg/kg orally for a total of 5 days. Chait et al described this triple antibiotic regimen in 163 pediatric patients with no immediate postprocedural complications and development of cecostomy-site infection in 6% patients over 7-year follow-up of 124 patients.[19,21]
3. Prophylactic gentamycin 2.5 mg/kg IV and metronidazole 10 mg/kg IV before and 2 days after procedure. Sierre et al used this regimen in a small cohort of 21 pediatric patients and reported no immediate postoperative complications.[22]

Hepatobiliary

Percutaneous Transhepatic Biliary Drainage and Cholecystostomy

Percutaneous transhepatic biliary drainage (PTBD), commonly performed in patients with biliary obstruction, is considered a contaminated and dirty procedure due to high incidence of bacterial proliferation secondary to stasis.[23,24] Infection, including cholangitis, pancreatitis, and sepsis, is one of the most common complications following biliary instrumentation.[25] Risk factors include advanced age, bilioenteric anastomosis, obstructive jaundice, previous percutaneous biliary procedure, acute cholecystitis, or diabetes mellitus.[26–28] According to the Biliary Drainage and Stenting Registry data, the incidence rates of major and minor septic events following PTBD were 2.5 and 7.7%, respectively, in 833 patients.[29] Preoperative antibiotics and bile cultures are a standard of care in patients undergoing PTBD as well as routine biliary tube exchanges. Positive bile cultures from prior PTBD, if available, should be used to guide prophylactic antimicrobial therapy for subsequent biliary interventions.[26]

If bile cultures are unavailable or negative, empiric treatment against *E. coli*, *S. viridans*, *Enterococcus*, *Klebsiella*, *Pseudomonas*, *Clostridium*, *Candida*, and *Bacteroides* species is warranted as the risk of bacteremia with any kind of biliary intervention is high.[1,26,30]

A majority of the acute cholecystitis patients requiring a cholecystostomy tube placement are already on antibiotic therapy. In patients who are not, antibiotic prophylaxis is required, as almost 50% of patients have positive bile cultures.[31]

Recommended Antibiotic Regimen

Suggested regimens for both PTBD and cholecystostomy tubes include (1) 1 g ceftriaxone IV; (2) 1.5 to 3 g ampicillin/sulbactam IV; (3) 1 g cefotetan IV plus 4 g mezlocillin IV; (4) 2 g ampicillin IV plus 1.5 mg/kg gentamycin IV. Vancomycin or clindamycin–gentamycin is recommended for penicillin-allergic patients.[1]

Percutaneous Liver Abscess Drainage

Pyogenic liver abscesses are commonly caused by *Klebsiella*, *Escherichia*, *Enterobacter*, *Streptococcus*, *Staphylococcus*, *Bacteroides*, and *Pseudomonas* species. The familiar underlying etiologies include extension of gallbladder and gallstone disease, diverticulitis, prior trauma or surgery, and seeding from sepsis. If antibiotic therapy has not been initiated, empiric treatment is recommended before drainage and continued postprocedure.

Recommended Antibiotic Regimen

Although there is no consensus on recommended empiric regimen, broad-spectrum agents such as meropenem, imipenem/cilastatin, doripenem, or piperacillin/tazobactam or combination of metronidazole with ciprofloxacin, levofloxacin, ceftazidime, ampicillin sulbactam, or cefepime have been used.[1,32]

Genitourinary

Percutaneous Nephrostomy Tube

Goodwin et al first described percutaneous needle drainage and tube placement for hydronephrosis in 1955.[33] Since then, the techniques and indications for percutaneous renal interventions have evolved. Nephrostomy tube placements are routinely performed for both dilated and nondilated systems. Indications include relieving obstruction, providing urinary diversion, access for endoscopic procedures, and diagnostic evaluation including pyelography and urinary perfusion.[34] Sepsis following percutaneous nephrostomy placement has been reported in 1 to 2% of patients, which can increase to 7% in cases with known pyonephrosis.[35–37] In patients with existing renal or urinary tract infections, the procedure is classified as contaminated or dirty and prophylactic antibiotics are required, if not already initiated. In patients without infection, the procedure is clean contaminated and existing evidence supports periprocedural antibiotic administration only in high-risk patients. Tandogdu and Wagenlehner reported a reduction of serious postoperative complications by 41% in high-risk patients, whereas no statistically significant difference was found between low-risk patients receiving prophylaxis and those who did not.[38] High-risk categories include patients with advanced age, diabetes mellitus, indwelling catheter, neurogenic bladder, bladder dysfunction, previous percutaneous ureteral procedures, and ureteroileal anastomosis.[39]

Although indwelling nephrostomy tubes provide a surface for biofilm formation and bacterial proliferation, the risk of clinically relevant infection remains low in the absence of catheter obstruction.[40] Prophylactic antibiotics are recommended only for routine catheter exchanges in high-risk patients (especially patients with ureteral stents, ureteroileal anastomosis, and indwelling urinary catheters) and those with catheter occlusion.[4,41]

Prophylaxis is recommended against *Escherichia coli*, *Proteus*, *Klebsiella*, and *Enterococcus* species.[1]

Recommended Antibiotic Regimen

The recommended regimens include (1) 1 to 2 g ceftriaxone IV single dose; (2) 1.5 to 3 g ampicillin/sulbactam IV every 6 hours + 5 mg/kg gentamycin IV single dose. Vancomycin is recommended in penicillin-allergic patients.

Abdominal Infections

Percutaneous Abdominal Abscess Drainage

Percutaneous abscess drainage carries a risk of rupture of abscess cavity and spillage of contents into surrounding spaces. If patients are not already on antibiotic therapy, empiric antibiotics should be started and continued postprocedure. Intra-abdominal abscesses are polymicrobial, and broad-spectrum antibiotics that cover anaerobic and gram-negative organisms such as *Enterobacter*, *Enterococcus*, *Bacteroides*, *Candida*, and *Pseudomonas* species are recommended.[42] The appropriate empiric antibiotic agents are selected according to the anatomical site as well as potential source of infection.

Recommended Antibiotic Regimen

SIR recommends single-agent regimens including meropenem, imipenem/cilastatin, doripenem, or piperacillin/tazobactam or combination of metronidazole with ciprofloxacin, levofloxacin, ceftazidime, ampicillin sulbactam, or cefepime.[1] The World Society of Emergency Surgery Consensus Conference 2017 guidelines[43] recommend piperacillin/tazobactam or cefepime plus metronidazole for critically ill patients with community-acquired intra-abdominal infections, and carbapenems, ceftolozane/tazobactam plus metronidazole and vancomycin or teicoplanin for critically ill patients with hospital-acquired infections. In patients with high risk of candidiasis, echinocandins should be administered.[43]

Paracentesis

Percutaneous drainage of ascitic fluid is considered a clean and safe procedure as ascitic fluid is usually sterile. The reported infection rates are less than 0.2%.[44,45] Cervini et al reported an infection incidence of 0.16% following 2,536 paracentesis without antibiotic prophylaxis.[45]

Recommended Antibiotic Regimen

Routine prophylactic antibiotics is not recommended, and no consensus exists regarding the use of antibiotics, but SIR recommends a single dose of prophylactic antibiotic targeting skin flora (*S. aureus*, *S. epidermidis*, *S. viridans*) in immunocompromised patients.[1] Patients with long-term tunneled catheters for palliative care can be administered 1 to 2 g cefazolin IV.[1]

Chest

Percutaneous Thoracostomy and Thoracentesis

Percutaneous chest tube drains can be placed for traumatic or spontaneous pneumothorax, hemothorax, pleural effusion, chylothorax, lung abscess, empyema, instilling sclerosing agents in the pleural space, and lysis of adhesions. Role of prophylactic antibiotics in patients without preexisting infectious foci is unclear.[46] A meta-analysis in 507 trauma patients who received a 24-hour regimen of cephalosporins prior to chest tube placements demonstrated a reduction in the development of pneumonia and empyema.[47] It is challenging to evaluate the adherence to aseptic techniques under such emergency settings. Thus, there is no consensus for use of empiric antibiotics prior to chest tube insertions. It is not recommended in older patients due to risk of *Clostridium difficile* infection.[48]

Drainage of pleural fluid is considered a clean and safe procedure with complications reported to be less than 2%.[46]

Recommended Antibiotic Regimen

Prophylactic antibiotics are not routinely indicated. SIR recommends a single dose of prophylactic antibiotic targeting skin flora (*S. aureus*, *S. epidermidis*, *S. viridans*) in immunocompromised patients.[1] Patients with long-term tunneled catheters for palliative care should be administered 1 to 2 g cefazolin IV.[1]

Lines

In the United States, the estimated annual occurrence of catheter-related bloodstream infections (CRBSIs) is a total of 250,000 cases,[49] out of which 80,000 occur in the intensive care units,[50] with an attributable mortality rate of 12 to 25%.[49] The most common causative agents are the skin flora organisms and those colonizing the catheter hub, including coagulase-negative *Staphylococci*, *S. aureus*, *Enterococci*, and *Candida* species.[51] Gram-negative rods account for 19% of total central line–associated bloodstream infections.[52] According to the 2017 Centers for Disease Control and Prevention (CDC) guidelines, routine administration of systemic antibiotics prior to catheter insertion is not recommended to prevent CRBSIs.[53] Infection control measures suggested by the CDC[53] include (1) educating and training health care personnel, (2) using maximum sterile barrier precautions during CVC insertion, (3) using more than 0.5% chlorhexidine skin preparation with alcohol for antisepsis, (4) avoiding replacement of CVCs, and (5) using antiseptic/antibiotic agent–impregnated short-term CVCs and chlorhexidine-impregnated sponge dressings if the rate of infection is not decreasing.

Tunneled Dialysis Catheters

Clinically significant bacteremia occurring at the time of catheter insertion is uncommon. A prospective study of 60 patients with uremia demonstrated a significantly lower occurrence of catheter loss caused by infection, tunnel-site infection, exit-site infection, and bacteremia following administration of a single dose of IV cefazolin before tunneled hemodialysis catheter placement over a follow-up period of 8 months.[54] Salman and Asif reported development of infection in 1 of 283 (0.35%) hemodialysis catheter placements and none in peritoneal catheter placements.[55]

Recommended Antibiotic Regimen

Even though there is conflicting evidence for the administration of systemic antibiotics prior to the insertion of tunneled catheters for dialysis, SIR recommends routine prophylaxis against skin flora irrespective of site of catheter insertion. Cefazolin 1 to 2 g IV and vancomycin in penicillin-allergic patients are recommended prior to placement of tunneled hemodialysis as well as peritoneal catheters.[1]

Antibiotic-impregnated catheters have been evaluated and shown to reduce CRBSIs in multiple studies.[56–59] Most of these studies include the use of short-term (<30 days), triple-lumen, uncuffed catheters in adult patients. Two trials on first-generation catheters that are coated with chlorhexidine/silver sulfadiazine on the external luminal surface have demonstrated reduction only in CRBSIs compared with standard catheters. Second-generation catheters coated with chlorhexidine/silver sulfadiazine on the external in addition to chlorhexidine coating the internal luminal surface have been shown to have a decreased incidence of catheter colonization as compared with standard catheters. Studies have shown lower rates of CRBSIs with the use of minocycline/rifampin-impregnated catheters compared with first-generation chlorhexidine/silver sulfadiazine and standard noncoated catheters.[56,59] The majority of studies on the use of a combination platinum/silver–impregnated catheter show no difference in the rates of CRBSIs.[60] The use of these catheters is limited by their high cost and development of antibiotic resistance.[60] Ethanol lock solutions also reduce CRBSIs and are inexpensive.[61–64] The CDC recommends using chlorhexidine/silver sulfadiazine or minocycline/rifampin-impregnated catheters or ethanol lock solutions if the rate of infection is not controlled despite adhering to at least three infection control measures: (1) education and training of healthcare professionals, (2) MSB precautions, and (3) more than 0.5% chlorhexidine preparations with alcohol for skin antisepsis.[53] SIR recommends using povidone iodine ointment or bacitracin/gramicidin/polymyxin B ointment at the hemodialysis catheter exit site after catheter insertion and at the end of each dialysis session, provided it is compatible with the catheter material.[60]

Tunneled Nondialysis Catheters

A review evaluating the effect of vancomycin, teicoplanin, and ceftazidime prior to insertion of tunneled catheter for chemotherapy in the reduction of gram-positive catheter-related sepsis demonstrated no significant difference (360

adults; risk ratio [RR]: 0.72, 95% confidence interval [CI]: 0.33–1.58; $p = 0.41$).[65] A prospective trial of prophylactic administration of vancomycin in patients receiving TPN reported 25% bacteriologically confirmed catheter-related sepsis which was not reduced by the prophylactic administration of vancomycin.[66]

Recommended Antibiotic Regimen

The use of prophylactic antibiotics is not recommended by the SIR for vascular tunneled nondialysis catheters, including peripherally inserted central catheters, except in immunocompromised patients (suggested regimen 1–2 g cefazolin IV).[1,60] Infection control guidelines issued by the CDC should be followed.[53] In patients with long-term pleural or peritoneal tunneled catheters for palliative care, 1 to 2 g cefazolin IV is recommended.[1]

Nontunneled Dialysis and Nontunneled Nondialysis Catheters

Nontunneled catheters are usually indicated for short-term use. Routine antibiotic prophylaxis for nontunneled hemodialysis as well as all other catheters is **not** recommended.[60] SIR recommends administration of 1 to 2 g cefazolin IV against skin flora in immunocompromised individuals.[1]

Route of Administration of Commonly Used Antibiotics

A majority of the antimicrobial agents are known irritants to the vessel wall and selection of inappropriate administration site can lead to vessel injury, phlebitis, thrombosis, catheter dislodgement, or infectious complications. International vascular access guidelines recommend that peripheral venous catheters should be avoided for infusing agents with pH <5 or >9, or osmolarity >900 mOsm/L.[67] Evidence from in vitro studies has established an increase in endothelial cell death as well as inhibition of DNA synthesis from agents with pH <5 or >9.[68,69] Certain agents demonstrate a wide pH range making this criterion ambiguous.[70] In addition to pH and osmolarity of the infusate, catheter material and size, treatment duration, and infusion rates also play a role in the risk of development of phlebitis.[71] Commonly used antibiotics and their preferred route of administration[72,73] have been summarized in ►**Table 2**. Certain antibiotics with preferred central catheter administration route may be administered via midline if central venous catheter is not available or not desirable.[74,75]

Conclusion

The appropriate use of prophylactic antibiotics plays a pivotal role in preventing infectious complications as well as reducing antibiotic resistance. There is a lack of evidence from randomized controlled trials to optimize the selection, dosing, and duration of prophylactic antibiotics in common IR procedures such as tube and line placements. Incorporation of the Society of Interventional Radiology guidelines and a regular review of recent evidence are essential to ensure optimal prevention of infectious complications.

Table 2 Administration of commonly used antibiotics in interventional radiology

Peripheral venous catheter	Midline[a]	Central venous catheter
Ampicillin	Ertapenem	Ampicillin/Sulbactam
Cefazolin	Daptomycin	Azithromycin
Cefepime[b]	Gentamycin	Ciprofloxacin
Ceftazidime[b]	Meropenem	Erythromycin
Ceftriaxone		Imipenem/Cilastatin
Cefotaxime		Levofloxacin
Metronidazole		Nafcillin
Penicillin		Oxacillin
Piperacillin		Vancomycin

[a]Central route is preferred but may be administered via a midline.
[b]Recent systematic review[73] demonstrated increase in the risk of vessel injury.

CONFLICT OF INTEREST
None declared.

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