Prophylactic Antibiotic Guidelines in Modern Interventional Radiology Practice

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ABSTRACT

Modern interventional radiology practice is continuously evolving. Developments include increases in the number of central venous catheter placements and tumor treatments (uterine fibroid therapy, radio- and chemoembolization of liver tumor, percutaneous radiofrequency and cryoablation), and new procedures such as abdominal aortic aneurysm stent-graft repair, vertebroplasty, kyphoplasty, and varicose vein therapies. There have also been recent advancements in standard biliary and urinary drainage procedures, percutaneous gastrointestinal feeding tube placement, and transjugular intrahepatic portosystemic shunts. Prophylactic antibiotics have become the standard of care in many departments, with little clinical data to support its wide acceptance. The rise in antibiotic-resistant strains of organisms in all hospitals worldwide have forced every department to question the use of prophylactic antibiotics. The authors review the evidence behind use of prophylactic antibiotics in standard interventional radiology procedures, as well as in newer procedures that have only recently been incorporated into interventional radiology practice.

KEYWORDS: Antibiotic, prophylactic, interventional radiology

Objectives: Upon completion of this article, the reader should be able to (1) state the correct timing of prophylactic antibiotic; (2) determine which procedures benefit from prophylactic antibiotics; (3) explain the potential infectious complication for each procedure; and (4) identify which patient groups are at increased risk for postprocedural infection.

Accreditation: Tufts University School of Medicine (TUSM) is accredited by the Accreditation Council for Continuing Medical Education to provide continuing medical education for physicians.

Credit: Tufts University School of Medicine designates this journal-based CME activity for a maximum of 1 *AMA PRA Category 1 Credit*™. Physicians should claim only the credit commensurate with the extent of their participation in the activity.

Prophylactic antibiotics (PR-ABXs) are widely used in interventional radiology (IR), from simple tunneled central venous catheter placement, to more complex tumor therapy-related embolization. Many interventional radiologists routinely give PR-ABXs, though there is little evidence in the literature to support this practice.

The routine and widespread use of broad-spectrum antibiotics has been responsible in part for the emergence of more virulent antibiotic-resistant bacteria in recent years,[1] and the doubling of methicillin-resistant *Staphylococcus aureus* (MRSA) infection rates in intensive care units over the past 10 years.[2] Not surprisingly, there is a direct MRSA infection rate with the prophylactic use

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Pharmacology in Interventional Radiology; Guest Editors, Kimi L. Kondo, D.O. and Charles E. Ray, Jr., M.D.

Semin Intervent Radiol 2010;27:327–337.
DOI: http://dx.doi.org/10.1055/s-0030-1267853.
ISSN 0739-9529.

of third-generation cephalosporins.[3] Likewise, the percentage of *enterococci* resistant to vancomycin has increased from 0.5% in 1989 to 25.9% in 1999.[4]

From physicians to hospitals to governments, there has been more critical examination of PR-ABX use and modification in clinical practice patterns.[1,3,5] Multiday therapy has changed to single-dose PR-ABX,[6] and in some cases PR-ABX is altogether eliminated.[7] Critical examination of PR-ABX use in IR must follow.

Surgical wounds are classified into four categories, each with a known infection risk. Clean wounds (no gastrointestinal [GI], genitourinary [GU] or respiratory tract access) carry an infection risk of <5%. Clean-contaminated wounds (where the GI, biliary, GU, or respiratory tract is entered without sign of infection and no break of aseptic technique) carry a 10% infection risk. Contaminated wounds (presence of infection or inflammation without pus) carry a 20% infection risk, whereas dirty wounds (clinically infected biliary or GU system or involving an abscess) carry a 39% infection risk.[8] Spies and McDermott suggested applying the wound classification to guide PR-ABX use.[8,9] PR-ABX use in IR has often been extrapolated from surgical data, which may overestimate the risk given smaller incisions with IR procedures.[10] PR-ABX use is generally accepted in clean-contaminated wounds, and in clean procedures where prosthetic material is implanted or where infection would be a significant threat to the patient.[11,12] Antibiotic use prior to contaminated or dirty procedures is essential but would be more correctly categorized as therapeutic, not prophylactic. Specific at-risk groups will differ for each type of procedure.[8,13]

Timing of PR-ABX is critical. Longer infusion intravenous (IV) antibiotics may be given within 2 hours prior to incision,[11] but short infusion IV antibiotic administration demonstrates greatest efficacy when given within 30 minutes prior to incision.[14] PR-ABX given after the surgical incision is less beneficial.[10] Direct correlation exists between the duration of surgery and the risk of infection.[6,13,15] In cases lasting greater than 4 hours, redosing of the antibiotic that was correctly given prior to surgery reduces the risk of infection.[14,16]

Our goals are to identify the procedures that would benefit from PR-ABX, identify the organisms likely to be problematic for a specific procedure, identify special patient groups most likely to be at risk for procedure-related sepsis, and recommend the antibiotic best suited for the procedure.

TUNNELED CENTRAL VENOUS CATHETER

Image-guided venous access procedures have low infection rates, even among patients who are immunocompromised. Catheter-related sepsis, or catheter-related bloodstream infection (CRBSI), is most commonly caused by coagulase-negative *Staphylococci* and *Enterococci*. Fungal infections due to *Candida* are also relatively common.

Infections are thought to be introduced through hub manipulation rather than related to colonization of the line at insertion. The infection risk for all central venous catheters in the intensive care unit (ICU) is estimated at 5.3 per 1000 catheter days.[4] In the United States, this results in 250,000 infections per year with a 12 to 25% mortality, at an average cost of $25,000 per infection.

There is no difference in infection rates between catheters placed in the operating room or IR suite,[17] even in neutropenic patients.[18] However, different infection rates are reported depending on the device. Totally implantable devices (ports) appear to have the lowest infection rates (0.1–0.9 per 1000 catheter days).[19,20] Ports are more resistant to infection as there is no external hub manipulation. In comparison, an infection rate of 1.8 to 2.5 per 1000 days is seen with Hickman catheters.[20] Dialysis catheters have an infection rate of 4.2 per 1000 catheter days[4] for cuffed catheters and 7.1 per 1000 catheter days for noncuffed catheters. Peripherally inserted central catheters (PICC) have the highest rates of infection (up to 8 per 1000 catheters days in oncology patients).[21]

There is no evidence to support routine use of PR-ABX prior to central venous catheter placement in adults. This is largely based on a meta-analysis of nine trials with 588 patients.[27] A recent article did not recommend routine antibiotic prophylaxis, but suggested administering cefazolin (1 g IV) if placing a totally implantable device or if the patient is immunocompromised.[22]

Despite the existence of any conclusive evidence supporting the use of PR-ABX, use of PR-ABX appears to be standard practice among members of the Society of Cardiovascular and Interventional Radiology (now the Society of Interventional Radiology)[23]; cefazolin (1 g IV) and vancomycin (1 g IV) have become standard of care in penicillin allergic patients. The Centers for Disease Control (CDC) discourages the use of prophylactic vancomycin for catheter placement due to its use increasing the risk of acquiring a vancomycin-resistant *Enterococci* (VRE) infections.[4]

There are higher rates of infections in certain subgroups, such as neutropenic and immunocompromised patients, but there is no robust evidence to support antibiotic use in theses populations. For example, higher rates of infection were reported in HIV patients compared with non-HIV patients in a prospective study of 391 patients, where all patients received PR-ABX.[24] Similar infection rates are seen in neutropenic patients as compared with those patients who are using their

catheter for total parenteral nutrition (TPN)[25] at the time of placement.

The main preventative strategy is therefore patient education and appropriate postprocedure catheter care. Also important are sterile technique, 2% chlorhexidine skin preparation, avoiding routine catheter changes, hand-washing, hub sterility, minimal catheter use, minimizing the number of lumens, and limiting number of caregivers using the catheter.[4,26] There is some evidence that the high-risk patient may benefit from flushing the catheter with antibiotic and heparin solutions,[27] locking the catheter with antibiotic solutions, and using catheters impregnated with antimicrobial agents (chlorhexidine and silver sulfadiazine or minocycline and rifampicin).[28]

VEIN SURGERY

Interventional radiologists are adding varicose vein procedures to their scope of practice. Endovenous thermal ablations and phlebectomy procedures[29] are being performed, often in an outpatient procedure room. Endovenous laser ablation (EVLA) has a very low risk of infection (0–0.1%) and requires no PR-ABX.[30,31] There is only a single case report of serious infection after EVLA; the patient presented with infection on the fifth postprocedure day, and required debridement and extensive local wound treatment.[32] Ambulatory phlebectomy also has a low risk of infection[33,34] and PR-ABX are also not recommended. No serious infective complications have been reported after isolated ambulatory phlebectomy. A single case of necrotizing fasciitis was reported after surgical stripping of the greater saphenous vein and ambulatory phlebectomy performed with tumescent anesthesia.

VERTEBROPLASTY AND KYPHOPLASTY

There are little data to support the routine use of PR-ABX for vertebroplasty or kyphoplasty procedures. There are only sporadic case reports of infection after vertebroplasty or kyphoplasty and, indeed, no infections were reported in a series of 1150 kyphoplasties after the administration of 1.5 g of cefuroxime.[35] However, given the serious morbidity associated with bone or cement implant infection, most operators choose to use PR-ABX.

When infections do occur, the most common bacteria are skin organisms such as *Staphylococci* and *Streptococci*; therefore, 1 g cefazolin,[22] 1.5 g cefuroxime,[35] or 600 mg clindamycin[36] are recommended antibiotics. Also of note, some operators use antibiotic-impregnated cement in which 1.2 g of tobramycin is mixed with the polymethyl methacrylate (PMMA) cement. There are no reported advantages of intravenous antibiotics over antibiotic-impregnated cement, or vice versa.

ARTERIOGRAPHY AND ENDOVASCULAR STENT PLACEMENTS

Diagnostic angiography is considered a clean procedure,[37] although bacteremia has been reported to occur in 4% of procedures. Transient bacteremia is seen in up to 32% of patients undergoing angioplasty but there is no associated increased risk of infection,[9,38] although in one study bacteremia was not seen in patients in the group who received PR-ABX.[38] Bacteremia is usually due to skin flora.

Although uncommon, septic complications after vascular procedures may be clinically significant. Septic arteritis leading to pseudoaneurysm formation has been reported after angioplasty and stent placement.[39,40] Factors increasing infection risk include repuncturing the same vessel, increased duration of stenting procedures, the presence of hematoma, surgery in the area of recent arterial access (<7 days), and immunosuppression.[41,42] There is no robust evidence justifying PR-ABX for routine percutaneous vascular interventions, but PR-ABX may be of benefit when there is high risk of infection.[43]

Prophylactic antibiotics are given routinely for initial placement of endovascular aortic reconstruction (EVAR); PR-ABX use is driven by fear of EVAR infection, which is rare (0.43%) but carries a high risk of mortality. Many patients (~30%) undergoing EVAR also require additional procedures, i.e., coil embolization and treatment of endoleaks, which are significant risk factors influencing the development of an infection. Other risk factors include immunosuppression, treatment of false aneurysms, and an infected central venous catheter. *Staphylococcus aureus* has been isolated in over one-half of the infections.[44] Although there is no conclusive data to support use of PR-ABX, in this patient population they may be indicated in patients undergoing multiple procedures related to EVAR repair within a short period.[45] In patients undergoing EVAR and in high-risk patients undergoing arterial intervention, single-dose cefazolin 1 g intravenously at the time of the procedure provides coverage against skin pathogens, like *Staphylococcus aureus* and *Staphylococcus epidermidis.* In patients allergic to penicillin, vancomycin is an alternative.[22,46]

ARTERIOVENOUS FISTULA AND GRAFT INTERVENTIONS

In a retrospective study by Salman and Asif, the incidence of clinical infection within 72 hours following routinely performed percutaneous procedures for hemodialysis access was 0.04%.[47] This study included 2078 cases of percutaneous balloon angioplasty in both arteriovenous (AV) grafts and fistulas, 106 cases of thrombectomy of an arteriovenous fistula, 110 cases of thrombectomy of an arteriovenous graft, 26 endovascular

stent insertions, and 31 intravascular coil placements.[47] Prophylactic antibiotics were not given in any of these procedures. The study concluded that PR-ABX are not necessary in routine interventional AV fistula-graft related procedures.

ARTERIAL EMBOLIZATION FOR GASTROINTESTINAL BLEEDING AND HYPERSPLENISM

Prophylactic antibiotics are not routinely given in patients undergoing embolization for posttraumatic or gastrointestinal bleeding.[46] Hemobilia is a rare situation where PR-ABX may be indicated, where accumulation of blood can lead to cholangitis from biliary obstruction. In this situation, PR-ABX recommended for biliary drainage procedures may be advisable.

In patients undergoing selective or partial splenic artery embolization for trauma or hypersplenism, PR-ABX are recommended.[48,49] The risk of splenic abscess and bacterial peritonitis increases when greater than 70% of total splenic volume is embolized; there is a 16% risk of infection with >70% of the spleen embolized compared with a 3% risk when 50 to 70% is embolized.[50] One recommend antibiotic regimen is the administration of 1 g of cefoperazone every 12 hours postprocedure for at least 5 days following the embolization procedure.[49] An alternative is to use embolic particles suspended in gentamicin (16 mg) in combination with a 5-day course of IV amoxicillin-clavulanate (3 g/day) and ofloxacin (400 mg/day).[50]

UTERINE EMBOLIZATION

Over 100,000 women worldwide have undergone embolization of the uterine arteries for treatment of fibroids[51] since Ravina et al published their original experiences.[52] Prophylactic antibiotic regimens have evolved from multiple-day, multidrug therapy to a single medication administered prior to the procedure. Some practitioners advocate using no PR-ABX at all.

Infectious complications include endometritis, leiomyoma infection, and myometrial infection secondary to uterine necrosis.[53] *Escherichia coli* (*E. coli*) is the most common pathogen.[54–56]

Early regimens involving multiday and multidrug therapy resulted in a high percentage (16.7%) of patients returning to the hospital with an infection. In addition, 2.4% of these patients ultimately required hysterectomy.[55] In one study, multidrug therapy given once prior to procedure resulted in lower rates of infection (2%), with only 0.8% of these cases leading to hysterectomy. However, vaginal discharge resulting from endometritis was seen in up to 58%, suggesting that aggressive PR-ABX led to imbalance of bacterial flora allowing the gram-negative bacteria to flourish.[54,57] More recent case series in the literature reflect a trend toward single dose of prophylaxis or no PR-ABX. A single dose of 1 g of cefazolin or 1 g of vancomycin are commonly used regimens.[58,59]

Two cases of death from sepsis postuterine embolization are reported in the literature[56,60]; overembolization and uterine necrosis are believed to be the inciting factors leading to infection, septic shock, diffuse intravascular coagulation (DIC), multiple organ failure, and ensuing death in the second patient.[61] In another series, ~5.9% of patients presented with minor infection and 2.6% of patients presented with septicemia requiring emergent myomectomy or hysterectomy.[62]

The risk of infection is increased with aggressive multiple-day antibiotic therapy,[57] overembolization (development of uterine necrosis),[60] and vaginal passage of sloughed fibroid material (possible ascending infection), which can occur in up to 7.7% of patients.[62] Studies that separated the infectious complications by patients who did and did not receive PR-ABX failed to show statistical significance between the two groups.[55,58]

The Royal College of Obstetricians and Gynaecologists state that there is insufficient data to recommend PR-ABX in patients undergoing uterine artery embolization.[51] If used, the current antibiotic of choice for prophylaxis, is a first-generation cephalosporin (cephazolin 1 g) or vancomycin (500–1000 mg IV).[45] Patients who are at high risk for pelvic infection may benefit from clindamycin (900 mg IV) and gentamicin (80 mg IV), which cover *Neisseria gonorrhoeae*, *Chlamydia trachomatis*, and anaerobic bacteria.[53]

VENOUS EMBOLIZATION

Varicocele embolization has very low complication rates and routine PR-ABX is not recommended.[22] Patients undergoing percutaneous sclerotherapy for vascular malformations, however, may benefit from a single dose of cefazolin (1 g IV) or vancomycin (1 g IV) prior to procedure.

TRANSJUGULAR INTRAHEPATIC PORTOSYSTEMIC SHUNT (TIPS)

Up to 10% of patients develop fever post-TIPS despite the use of PR-ABX. Whether the fever is secondary to actual infection of the TIPS (endotipsitis) or TIPS-induced bacteremia is unclear.[63]

Endotipsitis occurs in up to 1% of cases and is diagnosed when a febrile patient post-TIPS has positive blood cultures and thrombus or vegetation on the stent on imaging studies.[64,65] It is often a diagnosis of exclusion in a post-TIPS patient with persistent bacteremia and no other source of infection.[66] Patients with endotipsitis generally respond well to antibiotic treatment.[63,66] A broad spectrum of organisms including

fungi have been attributed to endotipsitis.[65] A randomized trial comparing no PR-ABX to single dose prophylaxis using 2 g cefotiam failed to demonstrate a significant difference in postprocedural infection.[67] At this time, PR-ABX is not recommended for routine TIPS patients.

In patients where difficulty in placement of the TIPS is anticipated, i.e., patients with partial thrombosis of portal vein, elevation of the right hemidiaphragm, or in difficult TIPS cases lasting several hours in duration, PR-ABX may be of greater value. In these instances, a single dose of cefazolin or ceftriaxone are two antibiotics that some practitioners use.[22]

PERCUTANEOUS TUMOR ABLATIONS

Within recent years, image-guided thermal ablation of localized tumor has become a viable treatment option for many patients. Ablation techniques include radiofrequency (RFA), microwave, laser, ultrasound, and cryoablation.[68] The use of these techniques has been extensively studied in liver tumors and their application is expanding into malignant lung, renal, and adrenal tumors as well as benign bone tumors.

Less than 1% of liver ablations result in infectious complications, the majority of which are hepatic abscess formation.[69–72] A study by Shibata et al found no statistically significant difference in infection rates between patients who did or did not receive PR-ABX.[72] The mechanism of infection posttumor ablation is not well understood, but may result from contamination of necrotic tissue. A bilioenteric communication may place the patient at increased risk for postablation abscess formation.[70] In addition, in a multicenter study by Livraghi et al the presence of a biloenteric anastomosis was a statistically significant risk factor for patients who developed infection postablation[71] In the same study, diabetic patients were also noted to be at high risk for developing infectious complications following hepatic ablation.[71] Similar risk factors are suggested in patients undergoing RFA of renal cell carcinoma. A case report of two patients with an ileal conduit who developed infectious complications despite receiving PR-ABX, suggests a similar mechanism of infection via colonization of the genitourinary tract.[73]

Mixed flora are seen in liver abscesses following ablation or embolization. In the single reported case of liver abscess following ethanol ablation, *E. coli*, *Clostridium perfringens*, and *Enterococcus* were isolated[74]

There are no randomized control trials to support the routine use of PR-ABX, but many operators use PR-ABX.[70–72] There is, however, empiric support for use of PR-ABX in high-risk patients who have previous bilioenteric anastomosis, biliary stasis/ductal dilation, severe cirrhosis, immunosuppression, diabetes, and concomitant infection.[68]

Single-dose or a short (few days) course of antibiotics may be effective in patients with sterile biliary systems. A single dose of ampicillin/sulbactam (1.5–3 g IV)[22,46] is recommended. However, with chronic biliary bacterial colonization as seen in bilioenteric anastomosis, or recent colonization following a biliary intervention procedure, a prolonged period of prophylaxis may be required to sterilize the biliary tract and prevent abscess formation. Multiday prophylaxis of cephazolin or cefmetazole (1 g IV) one day before ablation and every 12 hours until discharge,[72] or amoxicillin/clavulanate (Augmentin® 2 g IV; GlaxoSmithKline, Brentford, London, UK) immediately before the procedure and continued daily for 2 to 3 days[74] are two recommended regimens. Similar PR-ABX can be applied to ablation involving kidney, lung, and bone depending on clinical presentation.

LIVER TUMOR EMBOLIZATION

Catheter-directed embolization is currently a first-line treatment for unresectable hepatic tumors. Types of embolization include bland embolization, transarterial chemoembolization (TACE), and radioembolization (Yttrium-90 [Y-90] microspheres). An infected focus of tumor necrosis can lead to liver abscess, cholangitis, or frank sepsis.

TACE has been shown to have a very low rate of liver abscess formation. In two separate studies, three abscesses were seen in a series of 1348 cases,[75] and seven abscesses (one splenic and six hepatic) were seen in another series of 827 TACE sessions.[76] Patients who developed complications had risk factors including major portal vein obstruction, intrahepatic biliary obstruction, bilomas, ascites, and previous Whipple operation.[77] Patients with metastatic disease from a gastrointestinal primary exhibit a greater risk of infection after TACE, compared with primary liver tumors (7% vs 0.8%), respectively. This is thought to be due to preexisting compromise of bowel mucosal integrity by malignant ulcerative lesions.[78]

The incidence of liver abscess following radioembolization is also uncommon. In one study, only two cases of liver abscesses were seen in a series of 327 patients undergoing Y-90 radioembolizations.[79] In a review by Salem and Thurston on Y-90 radioembolization, it was concluded that apart from mild postembolization symptoms, most complications are due to nontarget embolization that can result in radiation-induced inflammation of the pancreas, lung, gallbladder, liver, and bowel.[81] For radioembolization, PR-ABX are not routinely recommended unless the patient presents with risk factor for infection, such as prior biliary surgery, diabetes, portal vein thrombosis, biliary obstruction, or gallstones. One antibiotic regime includes ampicillin-sulbactam (3 g IV) and vancomycin (1 g IV)

prior to the radioembolization procedure and during overnight hospitalization, and Augmentin® (875 mg orally every 12 hours for 5 days after discharge home). Ampicillin-sulbactam can be replaced with IV and oral ciprofloxacin in penicillin-allergic patients.

Infection from gas-forming anaerobes are common,[77,80,82] and the most frequent pathogen causing the liver abscess is *Klebsiella pneumoniae*.[83] PR-ABX regimes include broad-spectrum and anaerobic IV antibiotic coverage, such as IV cefazolin and metronidazole, prior to and during the hospitalization post-TACE, followed by a 5-day course of broad-spectrum oral antibiotics (Augmentin® or ciprofloxacin).[84] Routine bowel preparation is also advocated by some operators.

PERCUTAENOUS GI TUBE PLACEMENT

Gastrostomy (G), gastrojejunostomy (GJ), and jejunostomy (J) tubes can be placed percutaneously.[85,86] Radiologically placed catheters had lower risks for major infection, septicemia, and wound dehiscence when compared with endoscopically placed catheters (0.8% vs 3.3%, respectively).[87] There is a 3% risk of developing subcutaneous abscess and septicemia and 25% risk of minor infection in patients who did not receive PR-ABX.[88] Peristomal infection rates are reported to be as high as 38% following placement of G tubes with radiologic guidance in children, despite the use of PR-ABX.[89]

De novo placement of J tubes under fluoroscopic guidance is also becoming more common.[90,91] Local tube site infections associated with image-guided placement are usually polymicrobial and include *Staphylococcus aureus*, β-hemolytic *Streptococci*, and fungi.[85]

There is evidence that PR-ABX reduces infectious complication after endoscopic placement of G and GJ tubes, with fewer infections seen in those who received PR-ABX.[92–94] However, with the very low risk of readily treatable superficial infection, routine use of PR-ABX is difficult to justify. PR-ABX is recommended for patients at high risk for infection, such as malnourished pediatric patients and the immunocompromised. A single dose of cefazolin (1 g IV 30 minutes to 1 hour prior to the procedure),[93] or a 5-day regime of cefazolin (1 g IV) and cephalexin (500 mg twice daily [bid] orally or via gastrostomy) are reported. Clindamycin (600 mg IV and 600 mg bid orally or via gastrostomy for 5 days) can be substituted.[94]

BILIARY INTERVENTIONS

Biliary interventions encompass interventions where access to and drainage of bile are performed, either through the bile ducts directly or through the gallbladder.

Infective cholangitis (infection of the bile ducts), often involves retrograde ascent of organisms from the duodenum or from portal venous seeding. When colonization of a normally sterile biliary system occurs along with obstruction of its outflow, the increased pressure in the biliary system can "intravasate" organisms into the blood steam, resulting in sepsis.[95]

Enterococcus, *E. coli*, *Klebsiella*, and yeast are commonly encountered pathogens in the setting of cholangitis.[95,96] De novo access into the biliary system results in biliary systems that are 60% positive for organisms, but rises to 85% at 24 hours postprocedure, and to virtually 100% during exchange of the catheters. This suggests secondary colonization through catheter placement.[97] The use of PR-ABX can also change the biliary flora in patients undergoing multiple biliary procedures. A second biliary procedure (up to 7 days after the first) may carry increased risk for sepsis due to selective eradication of other organisms sensitive to the original PR-ABX.[98]

Randomized-controlled trials of PR-ABX prior to endoscopic retrograde cholangiopancreatography (ERCP) demonstrate no significant effect of PR-ABX, and therefore routine use is not recommended.[99] Likewise, the American Society for Gastrointestinal Endoscopy does not recommend routine use of PR-ABX performed for biliary obstruction in the absence of cholangitis and where complete drainage is anticipated. If incomplete drainage is anticipated, as in hilar strictures or primary sclerosing cholangitis, PR-ABX are recommended. The Society of Interventional Radiology, on the other hand, recommends PR-ABX in all patients undergoing percutaneous transhepatic biliary drainage (PTBD) procedures because there is an anticipated rate of sepsis of 2.5%.[100]

The question of whether or not to use PR-ABX usually arises in the setting of patients with no signs or symptoms of biliary sepsis prior to biliary access procedures. The use of antibiotics prior to percutaneous transhepatic cholangiogram should be considered on a case-by-case basis based on the risk factors and expected findings. Prophylactic antibiotics are recommended where inadequate or incomplete drainage is anticipated (hilar strictures, primary sclerosing cholangitis, biliary stones) or if the patient had a recent ERCP or PTBD (e.g., less than a week). Due to the anticipated colonization of the biliary catheter, PR-ABX are also recommended for routine catheter exchanges. Patients who are clinically septic should be treated with appropriate antibiotic therapy prior to the proposed procedure, and hence require no prophylaxis.

Piperacillin demonstrates good biliary excretion and coverage of the biliary bacterial flora[101] with decreased risk of nephrotoxicity. It is currently used more often in combination with tazobactam, which counters β-lactamase producing species of *E. coli* (Zosyn® 3.375 g IV; Wyeth Pharmaceuticals, Collegeville, PA).

Alternatives would be third-generation cephalosporins (ceftriaxone 1 g IV),[22] or ampicillin/sulbactam (1.5–3 g IV).[46]

PERCUTANEOUS NEPHROSTOMY

The use of PR-ABX in percutaneous nephrostomy (PCN) is directed toward preventing urosepsis from intravasation of organisms into the bloodstream occurring from manipulation of the infected urinary system.[22] Percutaneous nephrostomy tubes can be categorized from clean-contaminated (sterile hydronephrosis), to contaminated (in presence of infected stone disease), to dirty (in the presence of urosepsis or pyonephrosis), and the choice of PR-ABX therefore differs from true prophylaxis to treatment.[8,46] Even with appropriate PR-ABX, the rate of sepsis in PCN is as high as 2.2%, and as high as 7 to 9% in patients presenting with pyonephrosis.[23]

E. coli, *Klebsiella*, *Proteus*, and *Enterococcus* commonly cause urinary sepsis.[102] However, in patients with struvite stone disease, urease-producing bacteria, such as *Staphyloccocus aureus*, *Staphylococcus epidermidis*, *Pseudomonas aeruginosa*, *Micrococcus luteus*, and especially *Proteus mirabilis* may be found; it is noted that the bacteriology of the stone may not be reflected in urine culture.[103]

Patients who are at high risk for infectious complications include the elderly and those who are immunosuppressed, as well as patients with diabetes, stone disease, ureterointestinal conduits, renal insufficiency or voiding dysfunction, and previously instrumented patients who are suboptimally drained.[104]

The use of PR-ABX is not universally accepted in PCN. Some feel that PR-ABX is not indicated for use in routine PCN,[105,106] whereas others give multiday third-generation cephalosporins and gentamicin to all patients undergoing PCN.[107] For standard PCN in low-risk individuals, recommendations range from no PR-ABX to first-generation cephalosporins.[46,106] For patients at high risk for infection including those patients with calculi, broader coverage with ceftriaxone, ampicillin-sulbactam, ampicillin and gentamicin, or cephalosporin and gentamicin is recommended.[22,46,106] Although the choice of PR-ABX is important, it is as important to exercise good technique in performing PCN to prevent sepsis; overdistension of the renal collecting system or overmanipulation of an infected system can force bacteria into the blood system and cause sepsis.[46,108,109]

Other urinary tract procedures, such as suprapubic cystostomy, also have a relatively high rate (9%) of postprocedural sepsis.[110] A two-tiered antibiotic approach may be used in these patients. A one-time dose of a first-generation cephalosporin or single-dose gentamicin is appropriate for uncomplicated patients. Ampicillin-sulbactam, ampicillin with gentamicin, or a cephalosporin with gentamicin is recommended for high-risk patients or patients presenting with signs of infection.

Up to 17% of patients may present with bacteremia during nephrostomy catheter exchange,[111] regardless of periprocedural antibiotics. In patients who are undergoing a routine nephrostomy tube change, there is a lower risk of sepsis, and similar antibiotic prophylaxis that is used for low-risk percutaneous nephrostomy procedures can be used in these patients. Although there are practitioners who opt not to give a prophylactic antibiotic for routine catheter exchanges, there are situations where IV infusion of antibiotic may be invaluable (e.g., catheter malposition or malfunction).

FALLOPIAN TUBE RECANALIZATION

The use of PR-ABX is not universally recommended for fallopian tube recanalization.[112] If used, a 5-day course of doxycycline (100 mg orally twice daily, started 2 days prior to procedure), or doxycycline (200 mg orally immediately before the procedure followed by 100 mg orally twice daily for 5 days) are two regimens in the literature to prevent peritonitis postprocedure.[112–114] Ancef (1 g IV) or vancomycin (1 g IV) in patients with penicillin sensitivity are also alternatives.

NONINFECTED DRAINAGE PROCEDURES AND BIOPSY

There is no evidence to support the use of PR-ABX for percutaneous biopsy or drainage of noninfectious lesions such as lymphoceles or renal cysts.

Transrectal prostatic biopsy is the only biopsy procedure in which PR-ABX are currently recommended. Infectious complications include prostatitis and even Fournier gangrene. Based on a retrospective review of a series of 1018 TRUS biopsies, higher infections rates have been reported if no antibiotics are administered[115] Different complex regimes such as intramuscular gentamicin (80 mg 30 minutes before the procedure), and a 5-day course of ciprofloxacin (250 mg orally bid) have been reported.[8] A recent randomized study of 363 patients demonstrated no difference between an oral agent given once compared with a 3-day course.[116] Also, no difference was seen in a randomized study of 300 patients given either a single dose of fluoroquinolone before or after the procedure.[117] Although there is evidence to support the routine use of PR-ABX for transrectal prostatic biopsies, the actual antibiotic regime and timing do not appear to be critical.

ABSCESS DRAINAGE

Patients referred for percutaneous intraabdominal abscess drainage are almost invariably already being treated with

antibiotics; if the patient is not yet on antibiotics, initiation of treatment is recommended prior to drainage.[8,9]

CONCLUSION

Though there is largely a lack of robust data to support routine PR-ABX for most interventional procedures, there is a role for PR-ABX in several situations as described. For each procedure, it is important to understand the risk of infectious complications and the rationale for PR-ABX. Where the role for PR-ABX is debatable, or where there are several suggested regimes, we suggest that well-designed randomized controlled trials be conducted.

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