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Prevention of Infection After Gynecologic Procedures

Surgical site infection remains the most common complication of gynecologic procedures. Reducing surgical site infections has become a priority in the United States as part of a strong national commitment to measuring processes and improving outcomes of care for surgery. Implementing programs to reduce surgical site infections requires a collaborative approach that involves clinicians, nurses, and staff. The purpose of this document is to review the recommended interventions, including antibiotic prophylaxis, used to prevent infection after gynecologic procedures.

Background

Surgical site infections generally are defined as infections that occur after surgery in the part of the body where the surgery took place (1). These infections are classified as incisional or organ/space. Incisional surgical site infections are further divided into those involving only skin and subcutaneous tissue (superficial incisional) and those involving the deeper soft tissues of the incision such as muscle or fascia (2) (Box 1). In gynecologic surgery, surgical site infections that fit into these categories include superficial incisional cellulitis, deep incisional abscesses, and pelvic or vaginal cuff cellulitis or abscess formation (3). In a large cross-sectional analysis of the 2005–2009 American College of Surgeons' National Surgical Quality Improvement Program participant use data files, the rate of superficial incisional infection was 2.3–2.6% after total and supra-cervical abdominal hysterectomy and 0.6–0.8% after different types of laparoscopic hysterectomy. Deep incisional and organ/space infection (ie, vaginal cuff cellulitis, vaginal cuff abscess, peritonitis, and pelvic abscess) was noted in 0.5–1.2% of women having hysterectomy by any route (4).

Pathophysiology and Microbiology of Postoperative Infections

The risk of postoperative infection increases with the number and virulence of contaminating bacteria in the surgical site. The use of foreign material further increases the risk of infection. Systemic and local host immune mechanisms function to contain inoculated bacteria and prevent infection. Antibiotics in the tissues provide a pharmacologic means of defense to augment natural host immunity. Bacterial resistance mechanisms may contribute to the pathogenesis of surgical site infection by enabling organisms to evade the prophylactic antibiotics.

For most gynecologic surgical site infections, the pathogens arise from the endogenous flora of the patient's skin or vagina. When skin is incised, the exposed tissues are at risk of contamination with endogenous flora. These organisms usually are aerobic gram-positive cocci (eg, staphylococci), but may include fecal flora (eg, anaerobic bacteria and gram-negative aerobes) when incisions are made near the perineum or groin.

When the vagina is opened during surgery, the surgical site is exposed to a polymicrobial flora of aerobes and anaerobes. These operations are classified as clean-contaminated according to the Surgical Wound

Box 1. Criteria for Defining a Surgical Site Infection

Superficial Incisional: Occurs within 30 days postoperatively and involves only skin or subcutaneous tissue of the incision and the patient has at least one of the following: a) purulent drainage from the superficial incision, b) organisms isolated from an aseptically obtained culture of fluid or tissue from the superficial incision, c) at least one of the following signs or symptoms of infection: pain or tenderness, localized swelling, redness, or heat, and superficial incision is deliberately opened by surgeon and is culture-positive or not cultured (a culture-negative finding does not meet this criterion), and d) diagnosis of superficial incisional surgical site infection by the surgeon or attending physician.

Deep Incisional: Occurs within 30 days after the operative procedure if no implant is left in place or within 1 year if implant is in place and the infection appears to be related to the operative procedure, involves deep soft tissues (eg, fascial and muscle layers) of the incision, and the patient has at least one of the following: a) purulent drainage from the deep incision but not from the organ/space component of the surgical site, b) a deep incision spontaneously dehisces or is deliberately opened by a surgeon and is culture-positive or not cultured and the patient has at least one of the following signs or symptoms: fever (greater than 38°C) or localized pain or tenderness (a culture-negative finding does not meet this criterion), c) an abscess or other evidence of infection involving the deep incision is found on direct examination, during reoperation, or by histopathologic or radiologic examination, and d) diagnosis of a deep incisional surgical site infection by a surgeon or attending physician.

Organ/Space: Involves any part of the body, excluding the skin incision, fascia, or muscle layers, that is opened or manipulated during the operative procedure. Specific sites are assigned to organ/space surgical site infection to identify further the location of the infection (eg, endocarditis, endometritis, mediastinitis, vaginal cuff, and osteomyelitis). Organ/space surgical site infection must meet the following criteria: infection occurs within 30 days after the operative procedure if no implant is in place or within 1 year if implant is in place and the infection appears to be related to the operative procedure; infection involves any part of the body, excluding the skin incision, fascia, or muscle layers, that is opened or manipulated during the operative procedure; and the patient has at least one of the following: a) purulent drainage from a drain that is placed through a stab wound into the organ/space, b) organisms isolated from an aseptically obtained culture of fluid or tissue in the organ/space, c) an abscess or other evidence of infection involving the organ/space that is found on direct examination, during reoperation, or by histopathologic or radiologic examination, and d) diagnosis of an organ/space surgical site infection by a surgeon or attending physician.

Data from Horan TC, Andrus M, Dudeck MA. CDC/NHSN surveillance definition of health care-associated infection and criteria for specific types of infections in the acute care setting [published erratum appears in *Am J Infect Control* 2008;36:655]. *Am J Infect Control* 2008;36:309–32.

Classification system (Box 2) (5). Bacterial vaginosis is a complex alteration of vaginal flora resulting in an increased concentration of potentially pathogenic anaerobic bacteria. In studies performed before the routine use of antibiotic prophylaxis, it was associated with an increased risk of posthysterectomy cuff cellulitis (6–8). These microorganisms also can be spread to the abdominal incision at the time of surgery. In addition, the skin microorganisms *Staphylococcus epidermidis* and *Staphylococcus aureus* may lead to an abdominal incision infection. Gynecologic surgical procedures such as laparotomies or laparoscopies are classified as clean techniques as long as the vagina is not breached, and infections after these procedures typically are caused by infectious skin bacteria.

Procedures that breach the endocervix, such as hysterosalpingography (HSG), sonohysterography, intrauterine device (IUD) insertion, and endometrial biopsy meet the definition for clean-contaminated procedures, although even without antimicrobial prophylaxis, the risk of infection complicating these procedures is very low. Special circumstances such as a history of pelvic inflammatory disease (PID) or abnormal tubal architecture noted on HSG or at the time of laparoscopic chromotubation are associated with a risk of postoperative PID or endometritis and warrant perioperative antimicrobial prophylaxis. Choice of antimicrobials for the prevention and treatment of these postoperative infections should take into consideration their polymicrobial nature.

Box 2. Surgical Wound Classification

Class I/Clean: An uninfected operative wound in which no inflammation is encountered and the respiratory, alimentary, genital, or uninfected urinary tracts are not entered. In addition, clean wounds are primarily closed and, if necessary, drained with closed drainage. Operative incisional wounds that follow nonpenetrating (blunt) trauma should be included in this category if they meet the criteria.

Class II/Clean-contaminated: Operative wounds in which the respiratory, alimentary, genital, or urinary tracts are entered under controlled conditions and without unusual contamination. Specifically, operations involving the biliary tract, appendix, vagina, and oropharynx are included in this category, provided no evidence of infection or major break in technique is encountered.

Class III/Contaminated: Open, fresh, accidental wounds. In addition, operations with major breaks in sterile technique (for example, open cardiac massage) or gross spillage from the gastrointestinal tract, and incisions in which acute, nonpurulent inflammation is encountered, including necrotic tissue without evidence of purulent drainage (for example, dry gangrene), are included in this category.

Class IV/Dirty or Infected: Includes old traumatic wounds with retained devitalized tissue and those that involve existing clinical infection or perforated viscera. This definition suggests that the organisms causing the postoperative infection were present in the operative field before the operation.

Data from Centers for Disease Control and Prevention. Surgical site infection (SSI) event. Procedure-associated module. Atlanta (GA): CDC; 2018.

Antimicrobial Prophylaxis

The use of antimicrobial prophylaxis may be associated with adverse events. Longer duration of administration increases this risk. In its most severe form, pseudomembranous colitis, caused by *Clostridium difficile*, has been reported even after single-dose cephalosporin prophylaxis (9). The induction of bacterial resistance also is a potential result of the overuse of antibiotic prophylaxis, and more prolonged antibiotic administration increases this risk. Allergic reactions ranging in severity from minor skin rashes to anaphylaxis can occur.

Risk Factors for Postoperative Surgical Site Infection

Three categories of variables have proved to be reliable predictors of surgical site infection risk: 1) those that estimate the intrinsic degree of microbial contamination of the surgical site (Box 2), 2) the type and duration of surgery, and 3) those that serve as markers for host susceptibility (Box 3). Patients should be assessed for risk factors as part of preparation for surgery. At a systems level, two standardized methods of combining these risk factors are commonly used for analyzing and reporting infectious outcomes (10). The National Nosocomial Infections Surveillance System surgical infection risk index (11) uses three measures: 1) American Society of Anesthesiologists' physical status classification greater than 2; 2) wound class (Box 2) of III (contaminated) or IV (dirty-infected); and 3) procedure specific operative time greater than the 75th percentile (for hysterectomy, this is 2 hours). Each of these measures is awarded one point, for a possible total of three points. This index has poor predictive value for some procedures, for which procedure-specific models may be necessary (10). Alternately, the standardized infection ratio compares observed infection rates with the predicted number of infections adjusting for patient-related and procedure-related risk factors for each type of surgery.

Clinical Considerations and Recommendations

- *What preoperative and intraoperative strategies should be used to prevent surgical site infections?*

Preoperative Preventive Measures

Treat remote infection. All infections remote to the surgical site, such as skin or urinary tract infections, should be identified and treated before an elective operation. Elective operations on patients with remote site infections should be postponed until the infection has resolved (12).

Do not shave incision site. Hair should not be removed preoperatively unless the hair at or around the incision site will interfere with the operation. Any necessary hair removal should be done immediately before the operation, preferably with electric clippers. A razor should not be used. Patients should be instructed not to shave the operative site themselves because shaving with a razor increases their risk of infection (1, 3, 12–14).

Box 3. Patient Risk Factors for Surgical Site Infection

- Perioperative hyperglycemia
–Perioperative serum glucose greater than or equal to 180–200 mg/dL
- Smoking
- Obesity (BMI ≥ 30 or BMI Prime* ≥ 1.2)
- Nutritional status
- Depth of subcutaneous tissue ≥ 3 cm
- Coexistent infection at a remote body site (eg, skin, urinary tract)
- Vaginal colonization with microorganisms (eg, Group B streptococcal infection, bacterial vaginosis)
- American Society of Anesthesiologists Physical Status[†]
- Immunodeficiency (chronic steroid use, chemotherapy)
- MRSA status

Abbreviations: BMI, body mass index; MRSA, methicillin-resistant *Staphylococcus aureus*.

*Ratio of actual to upper limit BMI (currently defined as healthy BMI=25).

[†]American Society of Anesthesiologists. ASA physical status classification system. Washington, DC: ASA; 2014.

Data from Mahdi H, Goodrich S, Lockhart D, DeBernardo R, Moslemi-Kebria M. Predictors of surgical site infection in women undergoing hysterectomy for benign gynecologic disease: a multicenter analysis using the national surgical quality improvement program data. *J Minim Invasive Gynecol* 2014;21:901–9; Berrios-Torres SI, Umscheid CA, Bratzler DW, Leas B, Stone EC, Kelz RR, et al. Centers for Disease Control and Prevention guideline for the prevention of surgical site infection, 2017; Steiner HL, Strand EA. Surgical-site infection in gynecologic surgery: pathophysiology and prevention. *Am J Obstet Gynecol* 2017;217:121–8; Kwon S, Thompson R, Dellinger P, Yanez D, Farrohi E, Flum D. Importance of perioperative glycemic control in general surgery: a report from the Surgical Care and Outcomes Assessment Program. *Ann Surg* 2013;257:8–14; and Pellegrini JE, Toledo P, Soper DE, Bradford WC, Cruz DA, Levy BS, et al. Consensus bundle on prevention of surgical site infections after major gynecologic surgery. *Obstet Gynecol* 2017;129:50–61.

Control serum blood glucose levels and avoid perioperative hyperglycemia. Implement perioperative glycemic control and use blood glucose target levels of less than 200 mg/dL in patients with and without diabetes (1). Good preoperative diabetes mellitus control facilitates postoperative euglycemia. Preoperative diabetes screening can be performed for women at high risk who have not been recently screened. Diabetes (15) and poor glycemic control (16) are associated with

increased risk of surgical site infection. Good glycemic control is associated with lower rates of surgical site infections even in patients who do not have a preoperative diagnosis of diabetes mellitus. (3, 17, 18). In developing its guidelines, the Centers for Disease Control and Prevention (CDC) noted that its evidence search did not find any randomized trials using glucose targets less than 200 mg/dL (1). The two trials used to establish the 200 mg/dL target were both from cardiac surgery (19, 20). Other guidelines (21–23) use a target of 180 mg/dL. Collaboration with a diabetes management team may be beneficial. Whether stricter glycemic control improves outcomes is controversial. Implementation of an insulin infusion protocol for strict glycemic control lowered surgical site infection rates more than the previously used sliding scale insulin protocol in gynecologic oncology patients (18). A Cochrane review concluded that there was insufficient evidence to recommend strict control compared with conventional control (24).

Advise patients to shower or bathe (full body) with soap (antimicrobial or nonantimicrobial) or an antiseptic agent on at least the night before abdominal surgery (1). The 2017 CDC guidelines (1) recommend a preoperative bath or shower and do not specify any particular soap or antiseptic. This recommendation is consistent with several other guidelines (25, 26) and is an established, low-risk intervention based on low-quality evidence. The CDC guidelines, which cite a 2015 Cochrane review (27) that included seven randomized controlled trials, found no difference between agents (most frequently 4% chlorhexidine gluconate) and soap or placebo. A second meta-analysis also showed no benefit of whole-body bathing with soap compared with placebo or no bathing (28). The CDC did not make recommendations regarding use of chlorhexidine, optimal timing of washing, or number of applications.

Although the CDC guidelines and other major guidelines do not specifically recommend chlorhexidine, it is a reasonable choice based on limited evidence that suggests increased efficacy compared with soap or placebo. Data extracted from one large study included in the CDC evidence review found a statistically significant difference in favor of bathing with chlorhexidine (relative risk [RR], 0.36; 95% CI, 0.17–0.79) over no washing (29). In a 10-year prospective surveillance study, the surgical site infection rate was lower among patients showering with hexachlorophene before surgery than among those who did not shower or showered using a nonmedicated soap (30). In a retrospective study, preoperative showering with chlorhexidine was associated with a significantly

decreased risk of cellulitis after abdominal hysterectomy (odds ratio [OR], 0.2; 95% CI, 0.06–0.7) (31).

Perform preoperative surgical site skin preparation with an alcohol-based agent unless contraindicated (1). Chlorhexidine–alcohol is an appropriate choice. Chlorhexidine gluconate and iodophors have a broad spectrum of antimicrobial activity. Alcohol-based and aqueous-based types of each are commercially available, but chlorhexidine is most frequently alcohol based and iodophors aqueous based. Chlorhexidine appears to achieve greater reductions in skin microflora and has greater residual activity after application than povidone–iodine (32). In addition, unlike povidone–iodine, chlorhexidine is not inactivated by blood or serum proteins (12). In the CDC systematic review (1) (see eAppendix 1), meta-analysis of five randomized controlled trials (RCTs) that included 1,976 patients noted that chlorhexidine–alcohol was associated with a reduced risk of surgical site infection compared with aqueous iodophor (OR, 0.59; 95% CI, 0.42–0.83). The CDC review authors found no difference between chlorhexidine–alcohol and iodophor alcohol in a meta-analysis of six RCTs of 1,323 patients. In a prospective randomized clinical trial of 849 patients, preoperative cleansing of the patient’s skin with chlorhexidine–alcohol (2% chlorhexidine gluconate plus 70% isopropyl alcohol) was found to be superior (41% reduction in infections) to cleansing with 10% povidone–iodine for preventing superficial and deep incisional infection within 30 days after clean-contaminated surgeries including hysterectomy (33). There were no serious adverse events associated with the use of either type of antiseptic (33). In a retrospective cohort study of patients who underwent abdominal hysterectomy in the Michigan Surgical Quality Collaborative, patients who received preoperative chlorhexidine–alcohol-based skin antisepsis had a 44% lower odds of developing a surgical site infection compared with povidone–iodine (adjusted OR, 0.56; 95% CI, 0.37–0.85) (34).

Skin antiseptics should be used in accordance with their manufacturers’ instructions. For povidone–iodine scrubs for abdominal preparation, recommended scrub time can be as long as 5 minutes (35). The solution should then be removed with a towel and the surgical site painted with a topical povidone–iodine solution, which should be allowed to dry for 2 minutes before draping (35). Scrub time (gentle, repeated back-and-forth strokes) for chlorhexidine–alcohol preparations should last for 2 minutes for moist sites (inguinal fold and vulva) and 30 seconds for dry sites (abdomen), and allowed to dry for 3 minutes (36).

Vaginal cleansing with either 4% chlorhexidine gluconate or povidone–iodine should be performed

before hysterectomy or vaginal surgery. Currently, only povidone–iodine preparations are approved by the U.S. Food and Drug Administration (FDA) for vaginal surgical site antisepsis. The CDC (1) has recommended alcohol-based preparations, which typically include chlorhexidine, for external perioperative skin preparation, based on studies that suggest superiority over aqueous povidone–iodine preparations, raising the question of chlorhexidine use for vaginal surgical site antisepsis. In the United States, 4% chlorhexidine gluconate soap (containing 4% isopropyl alcohol) is often used off-label to prepare the vagina in women with iodine allergy, and some U.S. institutions prefer it for routine cases. To avoid irritation, chlorhexidine gluconate with high concentrations of alcohol (eg, 70% isopropyl alcohol, commonly used for skin preparation) is contraindicated for surgical preparation of the vagina. However, solutions that contain lower concentrations, such as the commonly used 4% chlorhexidine gluconate soap containing 4% alcohol, are usually well tolerated and may be used for vaginal surgical preparation as an alternative to iodine-based preparations in cases of allergy or when preferred by the surgeon.

Maintain appropriate aseptic technique. Surgeons should wash, prep, or scrub their hands and forearms up to the elbows according to manufacturer recommendations. Rigorous adherence to the principles of asepsis by all scrubbed personnel is essential to surgical site infection prevention. The CDC provides guidance regarding effective agents and techniques (37).

Minimize operating room traffic. Increased traffic in the operating room may increase infection risk. Implementation of a safety bundle that included decreasing the operating room door opening was associated with decreased surgical site infections (38). In a study of orthopedic trauma implant surgery, air quality diminished with increased door openings and number of people in the operating room (39). The Society for Healthcare Epidemiology of America and Infectious Diseases Society of America joint practice guidelines specifically recommend reducing unnecessary traffic in the operating room (21). Although the recommendation does not include specific details, it is reasonable to minimize the number of people in the operating room and limit the opening and closing of the operating room’s doors during the procedure to decrease the exposure to bacteria from nonfiltered air.

Intraoperative Preventive Measures

Minimize the risk of wound disruption. Excellent surgical technique is widely believed to reduce the risk

of surgical site infection. Such techniques include maintaining effective hemostasis while preserving adequate blood supply, preventing hypothermia, gently handling tissues, avoiding inadvertent entries into a hollow viscus, removing devitalized tissues, using surgical drains and suture material appropriately, eradicating dead space, and appropriately managing the postoperative incision (12, 21). Wound seroma increases the risk of abdominal wound infection. Although prevention of seromas would clearly be beneficial, there are no validated techniques for gynecologic procedures. Subcutaneous dead space closure has been shown to be effective and drain placement not effective for reducing surgical site infections during cesarean delivery (40), but it is unknown if these results generalize to nonpregnant patients. A systematic review of wound closure techniques for preventing infection in gynecologic surgeries (41) found a single RCT (42) that compared no closure, subcutaneous dead space closure, and drain placement in gynecologic oncology patients with 3 or more centimeters of subcutaneous fat and did not find a difference in surgical site infection rates.

Use appropriate antimicrobial prophylaxis. Antimicrobial prophylaxis generally is defined as a brief course of an antimicrobial agent initiated within 1 hour before a procedure begins (43). Antimicrobial prophylaxis is a critically timed adjunct used to reduce intraoperative microbial contamination to a level that can be contained by host defenses; it is not intended to prevent surgical site infection caused by postoperative contamination. The antimicrobial prophylaxis recommendations for gynecologic procedures are outlined in Table 1.

Administer an appropriate dose of antibiotic. For most antibiotics, including cefazolin, prophylaxis should be administered within 1 hour before skin incision. If quinolones or vancomycin are necessary, up to 2 hours is allowable (21, 43). Additional antimicrobial prophylaxis dosages or increased doses may be warranted in three circumstances:

1. *Patient is obese.* Prophylactic antibiotic dosage should be increased in obese patients. For all adult patients, the recommended usual dosage of cefazolin is 2 g given intravenously to ensure adequate levels of antibiotic at the operative site (21, 43), with a further increase to a 3-g intravenous dose of cefazolin for patients who weigh more than 120 kg (10, 21, 43, 44). Older studies and the previous version of this Practice Bulletin included the option of a 1-g dose, which can still be considered for women who weigh 80 kg or less. The use of a weight-based dosage is recommended based on expert opinion, without outcome studies showing a decreased rate of infection with increasing doses of antibiotic prophylaxis in obese patients. The rationale

for the use of a weight-based dosage includes pharmacokinetic studies that show decreased tissue levels of cefazolin in obese patients as well as the low cost and high safety profile of cefazolin (43). A 2-g dose for all patients who weigh 120 kg or less simplifies the regimen (43). Many experts also recommend the use of a weight-based dosage for vancomycin and gentamicin (21, 43).

2. *Lengthy procedure.* For lengthy procedures, additional intraoperative doses of an antibiotic, given at intervals of two times the half-life of the drug measured from the initiation of the preoperative dose, not from the onset of surgery, are recommended to maintain adequate levels throughout the operation (21, 43). Cefazolin should be redosed 4 hours from the preoperative dose.
3. *Excessive blood loss.* In surgical cases with excessive blood loss, a second dose of the prophylactic antibiotic may be appropriate (21, 43). Although most guidelines do not specifically define "excessive," a pharmacokinetic study (45) suggests an additional dose of cefazolin when blood loss exceeds 1,500 mL.

► ***Is preoperative screening for bacterial vaginosis before hysterectomy beneficial?***

Perioperative screening for bacterial vaginosis with treatment if present can be considered before hysterectomy as a possible means to decrease surgical site infections. Women with bacterial vaginosis have an increase in the vaginal concentration of microorganisms such as *Gardnerella vaginalis*, anaerobic microorganisms, and the genital mycoplasmas, which are potential pathogens that can cause postprocedural infection. In older studies performed before routine antibiotic prophylaxis, bacterial vaginosis was a clear risk factor for surgical site infection after hysterectomy (6, 46). In one study of patients who did not receive antimicrobial prophylaxis, preoperative and postoperative treatment of bacterial vaginosis with rectal metronidazole for at least 4 perioperative days significantly reduced vaginal cuff infection among women with abnormal vaginal flora but had no effect on the rate of wound infections (7). This study has not been replicated with the routine use of systemic antibiotic prophylaxis. However, given the low risk of bacterial vaginosis screening and treatment, screening for bacterial vaginosis during the preoperative visit and initiation of therapy with metronidazole or one of the other CDC-recommended treatment regimens (47) can be considered. If the therapy duration of 5–7 days encroaches on the scheduled time for surgery, it would be reasonable to continue therapy perioperatively for at least 4 days.

Table 1. Recommended Antibiotic Prophylactic Regimens by Procedure

Procedure	Antibiotic	Dose (single dose within 1 hour before procedure)*†
Hysterectomy (including supracervical) [‡] Vaginal Abdominal Laparoscopic Robotic	Cefazolin	2 g, 3 g IV for patients weighing >120 kg [§]
Uterine evacuation Suction D&C D&E	Doxycycline	200 mg
Colporrhaphy	Cefazolin	2 g, 3 g IV for patients weighing >120 kg ^{§¶}
Vaginal sling placement	Cefazolin	2 g, 3 g IV for patients weighing >120 kg ^{§¶}
Laparotomy without entry into bowel or vagina	Consider cefazolin	2 g, 3 g IV for patients weighing >120 kg ^{§¶}
Cervical tissue excision procedures (LEEP, biopsy, endocervical curettage)	Not recommended	
Cystoscopy**	Not recommended	
Endometrial biopsy	Not recommended	
Laparoscopic procedures without entry into bowel or vagina	Not recommended	
Hysterosalpingogram ^{††} Chromotubation Saline infusion sonography	Not recommended	
Hysteroscopy Operative Diagnostic	Not recommended	
Intrauterine device insertion	Not recommended	
Oocyte retrieval	Not recommended	
D&C for nonpregnancy indications	Not recommended	
Urodynamics**	Not recommended	

Abbreviations: D&C, dilation and curettage; D&E, dilation and evacuation; LEEP, loop electrosurgical excision procedure.

*In surgical cases with blood loss greater than 1,500 mL, a second dose of the prophylactic antibiotic may be appropriate (Anderson DJ, Podgorny K, Berrios-Torres SI, Bratzler DW, Dellinger EP, Greene L, et al. Strategies to prevent surgical site infections in acute care hospitals: 2014 update. *Infect Control Hosp Epidemiol* 2014;35[suppl 2]:S66–88; Bratzler DW, Dellinger EP, Olsen KM, Perl TM, Auwaerter PG, Bolon MK, et al. Clinical practice guidelines for antimicrobial prophylaxis in surgery. *American Society of Health-System Pharmacists, Infectious Diseases Society of America, Surgical Infection Society, Society for Healthcare Epidemiology of America. Am J Health Syst Pharm* 2013;70:195–283; and Swoboda SM, Merz C, Kostuik J, Trentler B, Lipsett PA. Does intraoperative blood loss affect antibiotic serum and tissue concentrations? *Arch Surg* 1996;131:1165–71; discussion 1171–2).

†For lengthy procedures, additional intraoperative doses of an antibiotic, given at intervals of two times the half-life of the drug measured from the initiation of the preoperative dose, not from the onset of surgery (for cefazolin this is 4 hours), maintain adequate levels throughout the operation (Bratzler DW, Dellinger EP, Olsen KM, Perl TM, Auwaerter PG, Bolon MK, et al. Clinical practice guidelines for antimicrobial prophylaxis in surgery. *American Society of Health-System Pharmacists, Infectious Diseases Society of America, Surgical Infection Society, Society for Healthcare Epidemiology of America. Am J Health Syst Pharm* 2013;70:195–283).

‡Screening for bacterial vaginosis in women undergoing hysterectomy can be considered.

§Joint guidelines from the American Society of Health-System Pharmacists, Infectious Diseases Society of America, Surgical Infection Society, and the Society for Healthcare Epidemiology of America recommend cefazolin 2 g as the standard prophylactic dose, with 3 g for patients who weigh more than 120 kg (Bratzler DW, Dellinger EP, Olsen KM, Perl TM, Auwaerter PG, Bolon MK, et al. Clinical practice guidelines for antimicrobial prophylaxis in surgery. *American Society of Health-System Pharmacists, Infectious Diseases Society of America, Surgical Infection Society, Society for Healthcare Epidemiology of America. Am J Health Syst Pharm* 2013;70:195–283). The rationale for the 2-g dose in all patients who weigh 120 kg or less is to simplify the dosage. Older studies and previous ACOG guidelines recommended a 1-g dose, which still can be considered for patients who weigh 80 kg or less.

|| Early pregnancy loss. Practice Bulletin No. 150. American College of Obstetricians and Gynecologists. *Obstet Gynecol* 2015;125:1258–67.

*| Antibiotic prophylaxis for colporrhaphy and vaginal sling placement is extrapolated from the standard prophylactic regimen recommended for other clean-contaminated vaginal procedures.

Although laparotomy without entry into bowel or vagina is classified as a clean procedure, single-dose antibiotic prophylaxis may be considered based on limited evidence that shows benefit (Morrill MY, Schimpf MO, Abed H, Carberry C, Margulies RU, White AB, et al. Antibiotic prophylaxis for selected gynecologic surgeries. Society of Gynecologic Surgeons Systematic Review Group. *Int J Gynaecol Obstet* 2013;120:10–5).

** Most units rule out urinary tract infection with a urinalysis before testing, with urine culture performed to confirm findings suggestive of infection. Patients with positive test results should be given antibiotic treatment.

†† Antimicrobial prophylaxis is recommended for women undergoing HSG or chromotubation with a history of PID or abnormal tubes noted on HSG or laparoscopy. For these women, an antibiotic prophylaxis regimen of doxycycline, 100 mg twice daily for 5 days, can be considered to reduce the incidence of postprocedural PID (Pittaway DE, Winfield AC, Maxson W, Daniell J, Herbert C, Wentz AC. Prevention of acute pelvic inflammatory disease after hysterosalpingography: efficacy of doxycycline prophylaxis. *Am J Obstet Gynecol* 1983;147:623–6; and Pereira N, Hutchinson AP, Lekovich JP, Hobeika E, Elias RT. Antibiotic prophylaxis for gynecologic procedures prior to and during the utilization of assisted reproductive technologies: a systematic review. *J Pathog* 2016;2016:4698314). For women undergoing chromotubation, a single preoperative 2-g dose of intravenous ceftazidime is recommended, and the patient can be discharged on the same doxycycline regimen recommended for abnormal HSG.

► **What antibiotic prophylaxis is appropriate for gynecologic procedures?**

Vaginal, Abdominal, Laparoscopic, or Robotic Hysterectomy

Patients undergoing vaginal, abdominal, laparoscopic, or robotic hysterectomy, including supracervical hysterectomy, should receive single-dose antimicrobial prophylaxis. Single-dose ceftazidime is currently recommended as the prophylactic antibiotic of choice for hysterectomy (43) (Table 1). Data from more than 30 prospective randomized clinical trials and four meta-analyses support the use of prophylactic antibiotics to reduce postoperative infectious morbidity and decrease length of hospitalization in women undergoing hysterectomy (48–50). A Cochrane review (51) showed reduction in total postoperative infections, abdominal wound infections, urinary tract infections (UTIs), pelvic infections, and postoperative fevers in women who received prophylaxis compared with placebo for abdominal hysterectomy and vaginal hysterectomy. The Cochrane review found insufficient evidence to conclude that any particular antibiotic regimen was superior. A retrospective review from the Michigan Surgical Quality Collaborative found lower infection rates among women who had prophylaxis with β -lactam antibiotic regimens (51). The Cochrane review found no studies of antibiotic prophylaxis for laparoscopic or robotic hysterectomy. However, given the similarities to other types of hysterectomies, antibiotic prophylaxis is likely beneficial for these procedures as well, and should be administered.

Other Laparoscopic and Laparotomy Procedures

Antibiotic prophylaxis is not recommended for patients undergoing diagnostic or operative laparoscopy (for indications other than hysterectomy) in which entry of the bowel or vagina is not anticipated (48, 52). Although laparotomy is classified as a clean procedure like laparos-

copy, single-dose antibiotic prophylaxis may be considered for laparotomy based on limited evidence that shows benefit (52). The Society for Gynecologic Surgeons Systematic Review Group conducted a meta-analysis of antibiotic prophylaxis for clean abdominal surgery not involving entry into the vagina or intestine. The authors found no reduction of infectious morbidity for patients undergoing laparoscopy, but concluded the evidence was poor. They found limited evidence supporting antibiotic prophylaxis for laparotomy (52). Antibiotic prophylaxis also may be considered for patients undergoing laparoscopy with a very high risk of conversion to laparotomy, given the potential benefit associated with laparotomy (52).

Hysterosalpingography, Chromotubation, Sonohysterography, and Hysteroscopy

The risk of infection associated with HSG and chromotubation is related to the patient's history of PID. Antimicrobial prophylaxis is recommended for patients undergoing HSG or chromotubation if they have a history of PID or their fallopian tubes are noted to be abnormal at the time of the procedure.

Pelvic inflammatory disease after HSG is an uncommon (1.4–3.4%) but potentially serious complication (53, 54). Patients with dilated fallopian tubes at the time of HSG have a higher rate (11%) of post-HSG PID (53). The possibility of lower genital tract chlamydial infection should be considered before performing this procedure. In a retrospective review, investigators observed no cases of post-HSG PID in patients with nondilated fallopian tubes (0/398) (53). In patients with no history of pelvic infection, HSG can be performed without prophylactic antibiotics. If HSG demonstrates dilated fallopian tubes, doxycycline, 100 mg twice daily for 5 days, is recommended to reduce the incidence of post-HSG PID (53). In patients with a history of pelvic infection, doxycycline can be administered before the procedure and continued if dilated fallopian tubes are found. Although there are no

specific studies, because chromotubation at the time of diagnostic laparoscopy is in many ways similar to HSG, application of the same prophylaxis regimen is reasonable. In patients thought to have an active pelvic infection, neither HSG nor chromotubation should be performed.

Routine use of antibiotic prophylaxis is not recommended for patients undergoing sonohysterography (55). No data are available on which to base a recommendation for prophylaxis in patients undergoing sonohysterography, which is technically similar to HSG. Reported rates of postprocedure infection are very low (56).

Antibiotic prophylaxis is not recommended for routine hysteroscopic procedures (52, 56). Infectious complications after hysteroscopic surgery are uncommon and estimated to occur in approximately 1–2% of patients (56, 57). In a systematic review of antibiotic prophylaxis for hysteroscopy, one study found four randomized trials (58–61) that showed no difference in postoperative infection after hysteroscopy between women who received antibiotic prophylaxis and those who received a placebo. Three were in diagnostic procedures, and the fourth (58) was in patients undergoing endometrial resection or ablation. An additional more recent RCT using cefazolin for operative hysteroscopy had similar findings (62).

Endometrial Ablation

Antibiotic prophylaxis is not recommended for endometrial ablation procedures. An older Cochrane meta-analysis that compared endometrial ablation techniques (eg, balloon, hydrothermal, microwave) found the incidence of endometritis to be 1.4–2.0%; myometritis, 0–0.9%; PID, 1.1%; and pelvic abscess, 0–1.1% (63). The only randomized trial of antibiotic prophylaxis in women undergoing transcervical hysteroscopic endometrial ablation or resection (58) found no difference in infection. The Society for Gynecologic Surgeons Systematic Review Group (52) suggests not using antibiotic prophylaxis for women undergoing hysteroscopic endometrial ablation. Similar recommendations seem appropriate for first-generation and second-generation techniques.

Intrauterine Device Insertion

Routine antibiotic prophylaxis is not recommended before IUD insertion (64, 65). For more information, see Practice Bulletin No. 186, *Long-Acting Reversible Contraception: Implants and Intrauterine Devices*.

Endometrial Biopsy

Routine antimicrobial prophylaxis is not recommended before endometrial biopsy. The literature search performed for this Practice Bulletin found no estimates of infectious complications of endometrial biopsy. The incidence is presumed to be negligible.

Uterine Evacuation

Antimicrobial prophylaxis should be administered to women undergoing uterine evacuation for induced abortion. In a meta-analysis of perioperative antibiotics to prevent infection after first-trimester abortion, use of prophylactic antibiotics reduced postabortal infection by 41% (15 trials, RR, 0.59; 95% CI, 0.46–0.75). The protective effect of antibiotics was demonstrable regardless of what subgroup was analyzed including women with a history of PID (five studies, RR, 0.55; 95% CI, 0.32–0.96), women with no reported history of PID (RR, 0.66; 95% CI, 0.47–0.90), and women who tested positive for chlamydial infection at the time of the procedure (two studies, RR, 0.14; 95% CI, 0.45–0.96) (66).

Antimicrobial prophylaxis should be administered to women undergoing uterine evacuation for early pregnancy loss. Because uterine aspiration for early pregnancy loss is the same procedure as for induced abortion, the infection risk should be similar. Although there are limited data specific to early pregnancy loss, it is reasonable to generalize the data from induced abortion and recommend antibiotic prophylaxis for women undergoing uterine aspiration for early pregnancy loss (67, 68). Antibiotic prophylaxis also is recommended for women undergoing second-trimester dilation and evacuation (69).

A Cochrane review found studies that showed effectiveness of a number of antibiotics, but only four studies that compared alternative regimens, and the review was unable to determine the most effective regimen (66). The Society of Family Planning concluded that doxycycline was the appropriate first choice because it was inexpensive, was equally effective when administered intravenously or orally, rarely caused allergic reactions, and had few adverse effects when given as a short course (67). The Society of Family Planning recommends a single or short course of doxycycline started preoperatively. Administration of a single 200-mg dose of doxycycline 1 hour before uterine aspiration to prevent postoperative infection is appropriate (68). Metronidazole is an appropriate second-line agent (67), with further support from a large retrospective series (70).

Colporrhaphy and Vaginal Slings

Patients undergoing anterior or posterior colporrhaphy or transvaginally placed slings are candidates for antimicrobial prophylaxis. The Society for Gynecologic Surgeons Systematic Review Group (52) identified two small randomized trials of antibiotic prophylaxis in women undergoing vaginal surgery without hysterectomy and concluded there was insufficient information to guide decision making. However, antibiotic prophylaxis is reasonable because the vaginal epithelium is

incised, and the resulting operative wound is classified as clean-contaminated (Box 2).

Antibiotic prophylaxis has been routinely used in studies that evaluated the effectiveness of transvaginally placed slings, including those using mesh. Case series of placement of midurethral slings suggest the risk of infection in these patients is low whether or not prophylaxis is administered (71, 72). A single randomized trial was stopped early because of low infection rates in both arms (73).

Postoperative Indwelling Catheters

The role of prophylactic antibiotics in patients with postoperative indwelling transurethral and suprapubic catheters is not clear. A Cochrane Review (74) noted limited evidence that prophylactic antibiotics reduced bacteriuria and other signs of infection in studies of men and women having a variety of surgeries and undergoing at least 24 hours of postoperative bladder drainage. In a randomized trial, prophylactic nitrofurantoin in patients with suprapubic catheters after urogynecologic surgery decreased symptomatic urinary tract infections up to 6 weeks postoperatively from 32.6% to 18.9% (75). A second randomized trial in women undergoing pelvic reconstructive surgery (76) did not show decrease in postoperative urinary tract infection with daily antibiotics. The Infectious Diseases Society of America guidelines recommend against prophylactic antibiotic administration for short-term and long-term catheterization, including in postsurgical patients, because of concerns about selection of antimicrobial resistance (77). Because most of these infections are mild and respond easily to treatment, it is unclear how to balance efficacy with concerns about resistance. Although limited evidence supports using ciprofloxacin, 250 mg, from postoperative day 2 until catheter removal in surgical patients with bladder drainage for at least 24 hours postoperatively (78), nitrofurantoin may be a more appropriate choice in light of the FDA warning about quinolones (79).

Urodynamic Studies

Routine antibiotic prophylaxis is not recommended for women undergoing urodynamic testing. A 2012 Cochrane review concluded that although antibiotic prophylaxis appears to reduce the risk of bacteriuria after urodynamic studies, there is not enough evidence to suggest reduction of symptomatic urinary tract infection (80). Because approximately 8% of women may have unsuspected asymptomatic bacteriuria (which can cause detrusor instability) at the time of urodynamic testing (81), pretest screening by urinalysis with urine culture performed to confirm findings suggestive of infection is recommended in women undergoing urodynamic testing. Patients with positive test results should be given antibiotic treatment (82, 83).

Cystoscopy

Antibiotic prophylaxis is not recommended for cystoscopy in women with negative urine cultures. The American Urologic Association (84) states that prophylaxis before cystourethroscopy “is probably not necessary if the urine culture shows no growth,” but acknowledges that this documentation may be lacking. Because most cystoscopy among gynecologic patients is done for incontinence, patients generally have urinalysis or culture as part of their evaluation, and a strategy of screening patients before cystoscopy and treating patients with bacteriuria is feasible. A meta-analysis (85) noted an overall reduction in infection (five studies, RR, 0.53; 95% CI, 0.31–0.90) and asymptomatic bacteriuria (six studies, RR, 0.28; 95% CI, 0.20–0.39) with antibiotic prophylaxis in a combination of studies of flexible and rigid cystoscopy. However, the authors noted significant concerns about bias in a number of the studies, particularly attrition and allocation concealment, and found no benefit in the subgroup of two studies that they rated as being at low risk of bias.

Cervical Tissue Excision Procedures (Loop Electrosurgical Excision Procedure, Biopsy, Endocervical Curettage)

Antibiotic prophylaxis is not necessary for cervical excision procedures, including loop electrosurgical excision procedure, biopsy, or endocervical curettage. The Society for Gynecologic Surgery Systematic Review Group (52) found two randomized trials of antibiotic prophylaxis in women undergoing loop electrosurgical excision procedures. Both trials had significant limitations, including prolonged antibiotic courses and use of surrogate outcomes, and one used a vaginal pessary that contained antibiotics. A Cochrane review (86) included an additional study. None showed any evidence of reduction in infection with prophylaxis.

Vulvectomy

The role of antibiotic prophylaxis for vulvectomy is not clear. The literature review performed for this Practice Bulletin found no prospective or randomized trials in this population. A retrospective review reported a 58% rate of wound infection after radical and modified vulvectomies performed for the treatment of vulvar cancer. However, the administration of antibiotic prophylaxis was not found to prevent wound infection (87). Because the microorganisms present on the skin of the vulva are polymicrobial, the procedure could be considered similar to a clean-contaminated surgery, for which single-dose prophylaxis with cefazolin is typically administered.

► ***Is antimicrobial prophylaxis indicated for assisted reproductive technology procedures such as egg retrieval and embryo transfer?***

A retrospective study of 526 oocyte donors who received antibiotic prophylaxis were compared with a group of 625 donors who did not. Infection was rare in the group that did not receive antibiotic prophylaxis (0.4%); no infection was found in the group that received antibiotics (88). Although the authors suggest that antimicrobial prophylaxis should be considered, there is little evidence to support its use (88). A systematic review (56) found similarly low baseline risk and no prospective trials. The authors suggest risk-based administration of prophylaxis to patients with a history of endometriosis, PID, ruptured appendicitis, or multiple prior pelvic surgical procedures based solely on theoretic concerns and two small case series of infections in patients with histories of endometriosis. Oocyte donors typically are prescreened for infection per FDA requirements (89).

Antibiotic prophylaxis is not recommended for embryo transfer. Both a recent systematic review (56) and the American Society for Reproductive Medicine Practice Committee (90) found no evidence that antibiotic prophylaxis prevents infection or improves pregnancy rate. A single randomized trial of amoxicillin and clavulanic acid on the day of the procedure compared with no antibiotics showed no difference in pregnancy rate or infection in 350 women undergoing embryo transfer (91). The American Society for Reproductive Medicine does not recommend prophylactic antibiotics for embryo transfer (90).

► ***What is the appropriate antibiotic prophylaxis regimen for patients with a history of (or with known) methicillin-resistant *Staphylococcus aureus* colonization or infection?***

For patients with a history of or known methicillin-resistant *Staphylococcus aureus* (MRSA) colonization or infection who are undergoing a procedure through a skin incision, use of a hospital-recommended MRSA antibiotic prophylaxis protocol or adjustment of the preoperative prophylactic antibiotic regimen to include a single preoperative intravenous dose of vancomycin is recommended (43). The updated CDC guidelines (1) make no comment on MRSA screening, decolonization, or prophylaxis. A systematic review and meta-analysis showed that patients identified as MRSA carriers who were decolonized and given MRSA-specific antibiotic prophylaxis were significantly protected (RR, 0.41; 95% CI, 0.30–0.56) against gram-positive surgical site infections in cardiac or orthopedic surgery (92). A second systematic review (93), including a broader range of patients and surgical types, also con-

cluded that decolonization with chlorhexidine and mupirocin is effective in decreasing MRSA-associated surgical site infection, but included a wider range of study types of lower quality. Neither systematic review found studies that included patients undergoing gynecologic procedures. Although universal preoperative screening for MRSA and routine decolonization are not recommended, it appears reasonable to ascertain a preoperative history for MRSA infection or colonization as well as to consider the status, if known, of patients screened for MRSA for alternative reasons. The joint guidelines of the American Society of Health-System Pharmacists, Infectious Diseases Society of America, Surgical Infection Society, and the Society for Healthcare Epidemiology of America recommend a dose of 15 mg/kg when using vancomycin for prophylaxis (43).

► ***What antimicrobial regimens are recommended for patients with penicillin allergy?***

Patients undergoing procedures in which antimicrobial prophylaxis is recommended may receive a cephalosporin if they do not have a history of an immediate hypersensitivity reaction (anaphylaxis, urticarial, bronchospasm) to penicillin. The combination of metronidazole or clindamycin plus gentamicin or aztreonam is recommended for patients in whom cephalosporins are contraindicated. Adverse effects to penicillin may be associated with the presence of the β -lactam ring structure and include allergic reactions ranging in severity from minor skin rashes to anaphylaxis. Anaphylaxis, the most immediate and life-threatening risk of prophylaxis, is rare. A β -lactam ring also is present in cephalosporins, and there is an increased risk of allergic reaction to first-generation cephalosporins in patients with histories of penicillin allergy, but not to second-generation or third-generation cephalosporins (94). The overall incidence of anaphylaxis from cephalosporins is quite rare, with rates of 0.0001% to 0.1% reported (94). Cephalosporin prophylaxis is acceptable in patients with a confirmed history of penicillin allergy that is not considered to be immunoglobulin E mediated (ie, no history of immediate hypersensitivity or anaphylaxis). Patients with a confirmed history of an immediate hypersensitivity reaction or exfoliative dermatitis (Stevens–Johnson syndrome, toxic epidermal necrolysis) to penicillin should not receive cephalosporin antibiotics, given that alternative drugs are available (43).

An alternative combination antibiotic prophylaxis regimen to protect against gram-positive microorganisms and gram-negative microorganisms is recommended for women with a confirmed history of immediate hypersensitivity to penicillin (Table 2) (43). Clindamycin or metronidazole alone has been shown to reduce infection after hysterectomy, but broader spectrum coverage results in even lower

Table 2. Antibiotic Prophylaxis Regimens in Patients With Immediate Hypersensitivity Reactions* to Penicillin

Agent	Dose	Half Life (h)	Interval to Repeat (h)
Clindamycin or Metronidazole	900 mg	2–4	6
PLUS [†]	500 mg	6–8	NA [†]
Gentamicin or Aztreonam	5 mg/kg [§]	2–3	NA [†]
	2 g	1.3–2.4	4

*Anaphylaxis, urticaria, or bronchospasm. Patients with exfoliative dermatitis (Stevens–Johnson syndrome, toxic epidermal necrolysis) from β -lactam antibiotics should also not receive cephalosporins.

[†]No repeat administration is needed.

[‡]Ciprofloxacin 400 mg is an additional effective alternative. Given the FDA warning (U.S. Food and Drug Administration. FDA Drug Safety Communication: FDA updates warnings for oral and injectable fluoroquinolone antibiotics due to disabling side effects. Silver Spring [MD]: FDA; 2017), its use should be restricted to patients for whom both gentamicin and aztreonam are not acceptable. Does not require repeat dosage.

[§]Dosage is based on the patient's actual body weight. If the patient's actual weight is more than 20% above ideal body weight (IBW), the "dosing weight" (DW) can be determined as follows: $DW = IBW + 0.4 (\text{actual weight} - IBW)$.

Data from Bratzler DW, Dellinger EP, Olsen KM, Perl TM, Auwaerter PG, Bolon MK, et al. Clinical practice guidelines for antimicrobial prophylaxis in surgery. American Society of Health-System Pharmacists, Infectious Diseases Society of America, Surgical Infection Society, Society for Healthcare Epidemiology of America. Am J Health Syst Pharm 2013;70:195–283.

infection rates. The combination of clindamycin or metronidazole *plus* gentamicin or aztreonam is recommended (Table 2) (43).

Prophylaxis with first-line cephalosporins may be more effective than with these second-line agents. In a retrospective review of hysterectomy patients from the Michigan Surgical Collaborative, surgical site infection rates were found to be greater in patients who received recommended alternatives than first-line cephalosporins (OR, 1.7; 95% CI, 1.27–2.07), which emphasizes the need to correctly assess allergy history and ensure all appropriate patients get first-line choices (51).

► *What is the role of safety bundles in decreasing surgical site infection?*

Hospitals should implement safety bundles to decrease surgical site infection. *Quality or safety bundles* are collections of evidence-informed practices aimed to improve care outcomes. They provide a framework to ensure that a complicated list of evidence-informed practices, like those presented in this Practice Bulletin, can be implemented in an organized way. A systematic review of studies that compared patient outcomes before and after bundle implementation found that low-quality evidence suggests that negative outcomes are less frequent after bundle implementation compared with usual care (95). Bundles have been validated for decreasing surgical site infection in colorectal, urologic, cardiac, and orthopedic surgery and for cesarean delivery (96–99). A consensus bundle on the prevention of surgical site infections after major gynecologic surgery has been published by the Council on Patient Safety in Women's Health Care and can be used for guidance (10). Enhanced

Recovery After Surgery programs are another type of approach to preoperative, perioperative, and postoperative care composed of comprehensive evidence-based practices with the goal of decreasing surgical stress or helping the body mitigate the consequences of such stress (100, 101). Additional bundles have been developed for major gynecologic cancer surgery (102), ovarian cancer surgery (103), and gynecologic cancer surgery involving the colon (104).

Bundles need to be complied with to be successful. A strong stepwise inverse association has been demonstrated between surgical site infection rates and the number of measures of a bundle followed (105). Bundles are also new and expected to evolve over time. Most bundles are developed by combining evidence-based interventions, often extrapolated from studies in other areas, and interventions based on expert opinion. Even interventions strongly supported by evidence are unlikely to have been validated in combination with other interventions in the bundle. Bundles should be revised over time as new interventions and new evidence about already included interventions become available.

Summary of Recommendations

The following recommendations are based on good and consistent scientific evidence (Level A):

- Implement perioperative glycemic control and use blood glucose target levels of less than 200 mg/dL in patients with and without diabetes.

- ▶ Perform preoperative surgical site skin preparation with an alcohol-based agent unless contraindicated. Chlorhexidine–alcohol is an appropriate choice.
- ▶ Patients undergoing vaginal, abdominal, laparoscopic, or robotic hysterectomy, including supracervical hysterectomy, should receive single-dose antimicrobial prophylaxis.
- ▶ Routine antibiotic prophylaxis is not recommended before IUD insertion.
- ▶ Antimicrobial prophylaxis should be administered to women undergoing uterine evacuation for induced abortion.

The following recommendations are based on limited or inconsistent scientific evidence (Level B):

- ▶ Advise patients to shower or bathe (full body) with soap (antimicrobial or nonantimicrobial) or an antiseptic agent on at least the night before abdominal surgery.
- ▶ Antibiotic prophylaxis is not recommended for routine hysteroscopic procedures.
- ▶ Routine antibiotic prophylaxis is not recommended for women undergoing urodynamic testing.

The following recommendations are based primarily on consensus and expert opinion (Level C):

- ▶ All infections remote to the surgical site, such as skin or urinary tract infections, should be identified and treated before an elective operation. Elective operations on patients with remote site infections should be postponed until the infection has resolved.
- ▶ Hair should not be removed preoperatively unless the hair at or around the incision site will interfere with the operation. Any necessary hair removal should be done immediately before the operation, preferably with electric clippers. A razor should not be used. Patients should be instructed not to shave the operative site themselves because shaving with a razor increases their risk of infection.
- ▶ Vaginal cleansing with either 4% chlorhexidine gluconate or povidone–iodine should be performed before hysterectomy or vaginal surgery.
- ▶ Administer an appropriate dose of antibiotic. For most antibiotics, including cefazolin, prophylaxis should be administered within 1 hour before skin incision. If quinolones or vancomycin are necessary, up to 2 hours is allowable.
- ▶ Prophylactic antibiotic dosage should be increased in obese patients.
- ▶ For lengthy procedures, additional intraoperative doses of an antibiotic, given at intervals of two times the half-life of the drug measured from the initiation of the preoperative

dose, not from the onset of surgery, are recommended to maintain adequate levels throughout the operation.

- ▶ In surgical cases with excessive blood loss, a second dose of the prophylactic antibiotic may be appropriate.
- ▶ Routine use of antibiotic prophylaxis is not recommended for patients undergoing sonohysterography.
- ▶ Antimicrobial prophylaxis should be administered to women undergoing uterine evacuation for early pregnancy loss.
- ▶ For patients with a history of or known MRSA colonization or infection who are undergoing a procedure through a skin incision, use of a hospital-recommended MRSA antibiotic prophylaxis protocol or adjustment of the preoperative prophylactic antibiotic regimen to include a single preoperative intravenous dose of vancomycin is recommended.
- ▶ Patients undergoing procedures in which antimicrobial prophylaxis is recommended may receive a cephalosporin if they do not have a history of an immediate hypersensitivity reaction (anaphylaxis, urticarial, bronchospasm) to penicillin. The combination of metronidazole or clindamycin plus gentamicin or aztreonam is recommended for patients in whom cephalosporins are contraindicated.

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The MEDLINE database, the Cochrane Library, and the American College of Obstetricians and Gynecologists' own internal resources and documents were used to conduct a literature search to locate relevant articles published between January 2000 and January 2018. The search was restricted to articles published in the English language. Priority was given to articles reporting results of original research, although review articles and commentaries also were consulted. Abstracts of research presented at symposia and scientific conferences were not considered adequate for inclusion in this document. Guidelines published by organizations or institutions such as the National Institutes of Health and the American College of Obstetricians and Gynecologists were reviewed, and additional studies were located by reviewing bibliographies of identified articles. When reliable research was not available, expert opinions from obstetrician–gynecologists were used.

Studies were reviewed and evaluated for quality according to the method outlined by the U.S. Preventive Services Task Force:

- I Evidence obtained from at least one properly designed randomized controlled trial.
- II-1 Evidence obtained from well-designed controlled trials without randomization.
- II-2 Evidence obtained from well-designed cohort or case–control analytic studies, preferably from more than one center or research group.
- II-3 Evidence obtained from multiple time series with or without the intervention. Dramatic results in uncontrolled experiments also could be regarded as this type of evidence.
- III Opinions of respected authorities, based on clinical experience, descriptive studies, or reports of expert committees.

Based on the highest level of evidence found in the data, recommendations are provided and graded according to the following categories:

Level A—Recommendations are based on good and consistent scientific evidence.

Level B—Recommendations are based on limited or inconsistent scientific evidence.

Level C—Recommendations are based primarily on consensus and expert opinion.

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