Consensus Bundle on Prevention of Surgical Site Infections After Major Gynecologic Surgery

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The Council on Patient Safety in Women's Health Care developed a consensus driven bundle of action steps to reduce surgical site infection after major gynecologic surgery.

Surgical site infections are the most common complication of surgery in the United States. Of surgeries in women of reproductive age, hysterectomy is one of the most frequently performed, second only to cesarean birth. Therefore, prevention of surgical site infections in women undergoing gynecologic surgery is an ideal topic for a patient safety bundle. The primary purpose of this safety bundle is to provide recommendations that can be implemented into any surgical environment in an effort to reduce the incidence of surgical site infection. This bundle was developed by a multidisciplinary team convened by the Council on Patient Safety in Women's Health Care. The bundle is organized into four domains: Readiness, Recognition and Prevention, Response, and Reporting and Systems Learning. In addition to recommendations for practice, each of the domains stresses communication and teamwork between all members of the surgical team. Although the bundle components are designed to be adaptable to work in a variety of clinical settings, standardization within institutions is encouraged.

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With more than 400,000 inpatient procedures occurring in the United States in 2010, hysterectomy is the most common gynecologic surgical procedure and second most frequently performed major surgery for women of reproductive age, second only to cesarean birth.[1–3] Estimates suggest that one in nine women will undergo hysterectomy during her lifetime.[4] In addition to hyster-

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ectomy, there are many other major gynecologic surgeries performed daily. Across health care, surgical site infections are the most common surgical complication, with an estimated 157,500 inpatient surgical site infections occurring in the United States each year.[5] Rates of surgical site infection can vary widely by type of procedure performed and by approach used for a single procedure. Despite recent increases in the rate of minimally invasive procedures, the majority of hysterectomies continue to be performed abdominally (54.2%), followed by vaginally (16.7%), laparoscopically (8.6%), and robotically (8.2%).[1] Rates of infection have been reported at 3.9% for open hysterectomy and 1.4% for minimally invasive procedures.[6] As recognized by Lachiewicz et al, gynecologic procedures pose a unique challenge in that potential pathogenic microorganisms may come from the skin or ascend from the vagina and endocervix to the operative site and can result in vaginal cuff cellulitis, pelvic cellulitis, and pelvic abscesses.[7]

Despite national efforts to reduce the incidence of surgical site infections, including the introduction of the Joint Commission's Surgical Care Improvement Project in 2006, infections at the surgical site continue to place a substantial burden on the U.S. health care system.[8,9] Patients who develop surgical site infections are twice as likely to die, 60% more likely to spend time in an intensive care unit, and more than five times more likely to be readmitted to the hospital than patients without surgical site infection.[9] In a 2015 study on unplanned 30-day readmissions, Merkow et al found that surgical site infection was the most common reason for unplanned readmission after hysterectomy, with 28.8% of total readmissions attributable to infection.[10] The cost per patient for those readmitted with surgical site infection after a nonobstetric inpatient or outpatient operating room procedure is on average $5,086 more than the cost per patient for those readmitted without infection of the surgical site.[8] Further, in addition to costs associated with a hospital readmission, patients with surgical site infections are also more likely to visit an emergency room, have twice as many ambulatory visits, and are more likely to require home health services, radiology testing, and the use of durable medical equipment than patients without postdischarge infections.[8]

Given the number of gynecologic surgical procedures performed, coupled with the rates of infection and their link to increased morbidity and mortality,[9] the Council on Patient Safety in Women's Health Care, a collaborative entity convened by the American College of Obstetricians and Gynecologists, recognized that the potential for effect through efforts aimed at reduction of surgical site infection rates in women undergoing gynecologic surgery was significant. To drive this work, the Council formed a workgroup of subject matter experts to develop a consensus bundle on the topic. The bundle, "Preventing Surgical Site Infections Following Major Gynecologic Surgery," is not designed to be prescriptive or to introduce new guidance, but serves to compile existing guidelines and evidence-based recommendations into a consumable product that can be easily and rapidly implemented based on the resources available within an individual organization. Given its prevalence, the authors have discussed hysterectomy at length; however, the elements of the bundle are designed to be applied to all gynecologic surgical procedures.

The bundle is organized into four domains: *Readiness, Recognition and Prevention, Response, and Reporting and Systems Learning*. There are 15 elements within the four domains (Box 1). These elements should serve as a starting place for organizations. Although it is recommended that each element be fully implemented, the elements can be modified for use based on the resources available within an implementing organization. The bundle was developed via a consensus-driven process in which the workgroup received and incorporated feedback from the multidisciplinary membership of the Council. The workgroup includes official representatives from the American Association of Nurse Anesthetists, the American College of Obstetricians and Gynecologists, the American College of Osteopathic Obstetricians and Gynecologists, the American Society of Anesthesiologists, the American Urogynecologic Society, the Association of Women's Health, Obstetric and Neonatal Nurses, and the Society for Gynecologic Oncology.

Readiness (Every Facility)

The *Readiness* domain includes six areas of focus to be addressed by every facility to prevent surgical site infections.

1. Standardize Preoperative Care Instructions and Patient Education Materials

Providing preoperative care instructions and patient education materials to women undergoing major gynecologic surgery affects both the surgical procedure and the recovery through reductions in length of stay and requests for pain medication, along with increased patient and family satisfaction.[11] Studies have shown that 40–80% of the medical information patients receive is forgotten immediately and nearly half of the information retained is incorrect.[12] Patient anxiety and fear will cause additional learning barriers. Therefore, beginning the process in the outpatient setting allows for reinforcement and the ability to effectively address additional patient and family concerns throughout the continuum of care. In addition to starting education early, it is imperative to potentiate the patient's best forum for learning. Using several modalities, such as verbal, written pamphlets and instruction sheets, video, and simulated demonstration, reinforces the education process. The use of Teach Back techniques[13] also helps to assess the patient's compre-

Readiness (Every Facility)

1. Establish standard preoperative care instructions and education for women undergoing major gynecologic surgery (such as hysterectomy), including postoperative wound care instructions (written and verbal)
2. Establish a system that delineates responsibility for every member of the surgical team
3. Establish standards for temperature regulation with regard to:
   - Ambient operating room temperature
   - Patient normothermia
4. Standardize the selection and timing of administration of prophylactic antibiotics, ideally using order sets or checklists
5. Standardize the timing of discontinuation of prophylactic antibiotics, ideally using order sets or checklists
6. Establish standard on appropriate skin preparation, both preoperatively and postoperatively

Recognition and Prevention (Every Patient)

7. Assess patient risk preoperatively for surgical site infection using the following criteria:
   - Blood glucose level
   - Body mass index
   - Immunodeficiency
   - Methicillin-resistant *Staphylococcus aureus* status
   - Nutritional status
   - Smoking status

Response (Every Case)

8. Develop intraoperative "Timeouts" to address antibiotic dosage, timing, prophylaxis issues, and patient-specific issues
9. Reassess patient risk for surgical site infection based on length of surgery, potential bowel incision, vaginal contamination, and amount of blood loss
10. Provide postoperative care instructions and education to women undergoing major gynecologic surgery (such as hysterectomy) and family members or other support persons

Reporting and Systems Learning (Every Facility)

11. Establish a culture of huddles for high-risk patients
12. Create system to analyze and report surgical site infection data
13. Monitor outcomes and process metrics
14. Actively collect and share physician-specific surgical site infection data with all surgeons as part of their ongoing professional practice evaluation
15. Standardize a process to actively monitor and collect surgical site infection data with postdischarge follow-up

Box 1. Prevention of Surgical Site Infections Following Major Gynecologic Surgery Patient Safety Bundle: Council on Patient Safety in Women's Health Care

Modified from Council on Patient Safety in Women's Health Care. Available at: http://www.safehealthcareforeverywoman.org/. Retrieved September 27, 2016.

hension and address unresolved issues. The development of teaching checklists assures standardization and thoroughness of education.

To optimize patient compliance related to the surgical procedure and reduce the risk of surgical site infection, the education process should include specific instructions and education related to:

- Preoperative showers (if applicable)
- Not shaving before the procedure
- Nothing by mouth
- Pre-existing medical conditions (if applicable)
- Antibiotic administration
- "What to expect" the day of surgery, such as the personnel involved, line placement, medications, monitoring devices, skin preparations, body warming devices, wound closure (subcuticular, negative pressure), and the immediate recovery
- Pain and pain management (pharmacologic as well as alternative therapies)
- Postoperative care and home environment preparations such as activity restrictions, follow-up visits, home support, and resources, including the need for home visits or phone call follow-up

2. *Delineate Responsibility for Members of the Surgical Team*

Preventing surgical site infections is a primary responsibility for every member of the perioperative team. Preventative measures to reduce surgical site infection are available but often do not identify the individual roles and responsibilities for the entire perioperative team, which includes the surgeon, anesthesia provider, nurse(s), and office-based staff. It is important that the roles and responsibilities of each team member

are clearly established before incision. Routinely, the surgeon assumes the overall responsibility for ordering prophylactic antibiotic and surgical scrubs and preparations and for providing preoperative and postoperative instructions to the patient. The office-based team coordinates with the surgeon to ensure that the patient is provided with written instructions regarding preoperative skin preparation as well as ensuring that the patient is given the appropriate preoperative cleansing solutions. In addition, the office-based team coordinates much of the communication between the surgeon and the surgical facility, nursing staff, and anesthesia provider as it relates to specific instructions and preoperative orders (including prophylactic antibiotics).

The role of the anesthesia provider is to ensure that antibiotics are given in a timely manner and to maintain normothermia and adequate, intraoperative glycemic control. Anesthesia providers are not routinely involved in the selection of the antibiotic but have a responsibility to ensure that appropriate antibiotic doses are administered and to ascertain whether a modification of the order is required, as with patients with a documented allergy, morbid obesity, or colonization with methicillin-resistant *Staphylococcus aureus* (MRSA). These variables may be noted by the surgeon during the preoperative evaluation; however, the anesthesia provider is responsible for performing a detailed history that may lead to a change in antibiotic choice. Any changes to the surgeon's preoperative orders need to be discussed with the surgeon as well as the entire surgical team.

The nursing team is routinely responsible for initiating the surgical scrub, ensuring the availability of ordered antibiotics, providing preoperative and postoperative care instructions, and ensuring that all Association of periOperative Registered Nurses recommendations and guidelines are followed before, during, and after the procedure.

Only the core expectations and responsibilities for each team member are discussed here. Institutions may modify these responsibilities based on need and patient presentation. However, if adding to a member's responsibilities, it is imperative that all the responsibilities are aligned with evidenced-based guidelines and standards.

3. Temperature Regulation

Temperature is among the most tightly regulated parameters in the body. The classical definition of hypothermia is a core body temperature of less than 35°C. The primary factors that influence normothermia include the type of anesthesia administered, the use of active warming devices during the surgical procedure, and the ambient operating room temperature. General anesthesia can have a profound effect on thermoregulation. Volatile inhalational agents, propofol, and opioids all result in a profound impairment of thermoregulatory mechanisms and a redistribution of core body heat to the periphery. Research has shown that core body temperatures may decrease as much as 1.6°C in the first hour after induction of general anesthesia.[14] Hypothermia results in an increase in thermoregulatory vasoconstriction, which leads to decreased tissue oxygenation and a direct impairment of immune function.[14,15] Therefore, it is important to ensure that normothermia is maintained during the surgical procedure, not only to help prevent surgical site infection, but also for promotion of overall patient comfort and metabolic needs.

In one of the first studies to assess the effect of hypothermia on surgical site infection incidence, Kurz et al[16] prospectively randomized 200 patients into one of two groups: one group was allowed to become hypothermic with body core temperatures of 34.5°C, and the other group had their core body temperatures maintained around 36.5°C. The authors reported that the hypothermic patients were more likely to exhibit peripheral vasoconstriction (78% compared with 22%) and to develop postoperative surgical site infections (19% compared with 6%), which supported the hypothesis that hypothermia promotes decreased immune activity and increased risk of surgical site infection.

Although the effect of temperature maintenance on surgical site infection is not definitive, there is no denying other benefits of normothermia; foremost among these is overall patient satisfaction and comfort.

The preservation of normothermia during the operative procedure is the primary responsibility of the anesthesia provider. The approach to perioperative warming can include multiple methods. The most common intervention for maintenance of normothermia is to provide warmed intravenous fluids with or without using a forced air warmer. Research has shown that after as little as 30 minutes of anesthesia, the use of warmed intravenous fluid is beneficial in preventing hypothermia, and heated forced-air warmers have a similar effect.[17,18] In a systematic review, Scott and Buckland[17] found that administration of both warmed intravenous fluids and forced air warming were effective in preventing hypothermia; the most frequently used method was forced air warming. These authors noted that maintenance of normothermia resulted in reduced complications such as pressure ulcers, blood transfusions, and postoperative cardiac events.

In 2015, the Association of periOperative Registered Nurses published a recommendation that the standard operating room temperature should be maintained between 68 and 72°F (20–25°C).[18] This recommendation is often ignored by practitioners owing to the discomfort the increased ambient temperature promotes among the surgical team. To help alleviate discomfort to the surgical team, one recommendation is to set the temperature to the recommended level (68–72°F) during induction

of anesthesia, placement of active warming devices, and surgical preparation and then decrease the temperature to a more comfortable level for the operating room staff and physicians. This practice was recently studied in one arm of a study, and it was reported that decreasing the ambient temperature once active warming methods had been deployed resulted in no instances of hypothermia.[19] Although only one study, it does support the practice employed in many surgical suites of reducing the ambient room temperature after administration of active warming.

4. Standardize Selection and Timing of Administration of Prophylactic Antibiotics

The foundation for antibiotic prophylaxis was established by Burke in 1961 when he showed a significant reduction in surgical site infections when antibiotics were administered before the surgical incision.[20] The Surgical Care Improvement Project measure set includes measures related to prophylactic antibiotic administration within 60 minutes before surgical incision, as well as antibiotic selection, redosing, and discontinuance.[21] Often the anesthesia provider is responsible for administering the antibiotics within 60 minutes before skin incision (120 minutes for antibiotics that require a slow infusion). These time frames are important because it has been demonstrated that administration of prophylactic antibiotics within 60 minutes of skin incision ensures that adequate serum and tissue concentrations are present at the time of incision.[21]

There have been multiple studies to evaluate the effectiveness of adhering to Surgical Care Improvement Project guidelines related to antibiotic prophylaxis. Study results have been mixed, with some research showing significant reductions in surgical site infections and some showing either no effect or an increased incidence of surgical site infection.[22–25] A possible explanation for these mixed findings could be a failure to comply with all of the guidelines outlined in the Surgical Care Improvement Project, primarily failure to administer the antibiotics in a timely manner. In 2005, Bratzler et al[26] reported that 44% of all hospitals in their study were noncompliant with antibiotic timing. Similarly, in 2013, Hawkins et al[27] reported antibiotic timing noncompliance was 27%, showing that although the timing issue has improved, it is far from resolved. Often the antibiotics are administered by the anesthesia provider in the preoperative holding area; this can result in antibiotics being administered well outside the recommended 60-minute window before skin incision.[25] Although the 60-minute time frame for administration is recommended, some have questioned whether it is optimal. To determine the optimal time for antibiotic administration, a 2009 multi-center study was done to examine the relationship between timing of administration and the incidence of surgical site infection.[28] These investigators used a variety of antibiotics; however, the most applicable findings to the gynecologic population were found in the cephalosporin trials, in which the reported overall incidence of surgical site infection was 4.7% when a cephalosporin was given more than 120 minutes before incision, 2.4% when given during the 31–60-minute time frame, and only 1.6% when given within 0–30 minutes before skin incision.[28] Based on these results, the authors recommended that all antibiotics can be most effective in preventing surgical site infection if given 0–30 minutes before skin incision.

An initiative that may prove to be beneficial in ensuring antibiotic timing compliance is to incorporate a question during the surgical timeout(s) that asks the anesthesia provider to verbalize the antibiotic type, dose, time of last administration, and time of possible redosing. When this verbalization is done, it alerts the entire surgical team to the antibiotic coverage and timing. Another factor to consider is the overall length of the surgical procedure, given that surgical time correlates with risk of infection. The risk of surgical site infection is only 6.3% for procedures less than 1 hour but increases to more than 28% for procedures lasting longer than 2 hours.[29] Based on this evidence, it is recommended that antibiotics should be redosed (if appropriate) for any surgical procedure lasting longer than 2–3 hours or when substantial blood loss (greater than 1,500 mL) occurs. A general rule is that antibiotics should be redosed at one to two times the half-life of the drug measured from the time the preoperative dose is administered.[22]

Antibiotic selection choices are fairly simple; studies and guidelines often recommend that the antibiotic choice should be based on the type of surgery and wound classification.[28,30,31] The prophylactic antibiotic regimen should include an agent effective against the most likely infecting organisms; most abdominal gynecologic procedures include a cephalosporin because they are active against the common skin pathogens *S aureus* and *Streptococcus* species. Table 1 identifies doses, administration regimens and half-lives for some of the most commonly administered antibiotics used in gynecologic surgeries.[22] However, it is important to recognize that some patients will require a modified antibiotic regimen in cases of penicillin allergy or infection with MRSA. If an altered antibiotic regimen is required, anesthesia providers and surgery staff need to collaborate to ensure that the proper regimen is administered within an acceptable time frame for surgical site infection prophylaxis.

Most often the surgeon will have an order set for the surgical procedure. This often includes patient-specific data such as the surgical procedure, weight and body mass index (calculated as weight (kg)/[height (m)]^2), allergies, and the antibiotic to be administered. In addition, many surgical teams use a checklist that includes all measures to prevent surgical site infection. The most commonly used checklist for surgical procedures is the

Antibiotic	Recommended dose	Half-life (with normal renal function)	Recommended redosing interval (from initiation of preoperative dose)
Ampicillin	2 g	1–1.9 hrs	2 hrs
Cefazolin	2 g *(3 g for patients weighing > 120 kg)*	1.2–2.2 hrs	4 hrs
Aztreonam	2 g	1.3–2.4 hrs	4 hrs
Cefuroxime	1.5 g	1–2 hrs	4 hrs
Cefoxtaxime	1 g	0.9–1.7 hrs	3 hrs
Cefoxitin	2 g	0.7–1.1 hrs	2 hrs
Cefotetan	2 g	2.8–4.6 hrs	6 hrs
Ceftriaxone	2 g	5.4–10.9 hrs	N/A*
Ciprofloxicin	400 mg	3–7 hrs	N/A*
Clindamycin	900 mg	2-4 hrs	6 hrs
Gentamicin	5 mg/kg *based on dosing weight†* (single dose)	2–3 hrs	N/A†
Vancomycin	15 mg/kg	4.8 hrs	N/A*

Table 1. Recommended Antibiotic Dosing and Redosing Intervals[36]

Abbreviation: N/A, not applicable.

*Antibiotics are typically redosed at an interval of two times the half-life in patients with normal renal function. N/A is typically cited in cases that typically do not require a redose for coverage, however you may need to consider redosing of antibiotic in procedures that are unusually long.

†Gentamycin prophylaxis is generally limited to a single dose given preoperatively. Dosing is based on the patient's actual body weight. In cases where the patient's actual weight is >20% over the ideal body weight (IBW), the dosing weight (DW) can be determined as follows: DW = IBW + 0.4(actual weight–IBW).

World Health Organization's 19-item surgical safety checklist.[32] This checklist is separated into three areas: sign in, timeout, and sign out. Antibiotics are addressed during the timeout phase of the checklist, but this does little to ensure that appropriate antibiotics are administered before the surgical timeout. Therefore, it is recommended that a checklist be placed on the preoperative chart or anesthesia record that includes the time, dose, and route of antibiotic administration as well as suggested redosing times, and that this information is then communicated during the surgical timeout, at the start of surgery, and at prescribed intervals during the surgical procedure.

5. Standardize the Timing of Discontinuation of Prophylactic Antibiotics

The current recommendation is that all prophylactic antibiotics be terminated within 24 hours of surgery completion, because there is no documented benefit in reduction of surgical site infection after skin closure. Antibiotics should be continued only when clear medical indications are present.[33,34] Research has shown that antibiotic prophylaxis continued after surgery is associated with antibiotic-related morbidity, emergence of antimicrobial resistance, and greater health care costs.[35] It is recommended that the surgeon use order sets or checklists to ensure that the antibiotics are discontinued if they are not warranted. With the emergence of electronic order sets, the hospital or pharmacy can set an electronic alert to warn surgeons if unwarranted postoperative antibiotics are ordered.

6. Appropriate Skin Preparation

Appropriate antisepsis of the surgical site before incision is critical to preventing surgical site infections. There are several approved agents currently available for use. To date, no single antiseptic has been identified as the most effective at preventing surgical site infections,[36] and currently only povidone-iodine preparations are approved for vaginal surgical site antisepsis. However, multiple investigators have explored the off-label use of chlorhexidine-alcohol.[37–39] In a retrospective cohort study conducted from 2012 to 2015, Bazzi et al found that patients receiving chlorhexidine gluconate in alcohol at the time of abdominal hysterectomy were 30% less likely to develop surgical site infections than patients receiving povidone-iodine in water.[39] There is still reluctance to use chlorhexidine gluconate for a surgical preparation of the vagina based on the product labeling and the need for additional studies.[36] One standard antiseptic agent is not likely to be uniformly optimal for every patient or every case; the multidisciplinary perioperative care team should work together to select the best skin preparation agent based on the patient's allergies and skin condition,

the manufacturer's recommendation for the agent, and surgeon preference.[40,41]

Recognition and Prevention (Every Patient)

The *Recognition and Prevention* domain identifies six risk factors that should be assessed for every patient.

7. *Assessing Patient Risk*

A number of risk factors are known to affect a patient's risk of developing a surgical site infection.[42] Although not all factors are modifiable, there are a number of factors that health care providers can evaluate and manage to increase the likelihood of a positive outcome. A selection of these factors has been identified by the authors for discussion. Although specific recommendations for each factor are not explored, it is recommended that the identified factors be evaluated for every patient before surgery.

• *Glycemic control.* It is estimated that 29.1 million people in the United States are living with diabetes. However, data further suggest that 8.1 million are unaware of their condition.[43] The significant number of undiagnosed cases drives the need for preoperative evaluation of every surgical patient to ensure identification of undiagnosed or uncontrolled diabetes. Further, postoperative hyperglycemia in nondiabetic patients can also increase the risk of surgical site infections.[44] In a 2015 study, researchers found that initiating intensive glycemic control for 24 hours after gynecologic oncology surgery in patients with diabetes mellitus and postoperative hyperglycemia lowered the surgical site infection rate by 35% compared with patients receiving intermittent sliding scale insulin.[45]

• *Body mass index.* Body mass index is positively correlated with a risk of wound complications and infection in women undergoing abdominal hysterectomy.[46] In a 2015 study, Shah et al found that rates of wound infection were 8.9% and 4.1% in morbidly obese and obese patients, respectively, compared with 1.4% in normal-weight patients.[46] Although health care providers may be unable to encourage a patient to lose weight before surgery, more aggressive administration and redosing of antibiotics is warranted in the obese and morbidly obese population.[46] Further, obese women may benefit from the use of subcutaneous sutures, talc application, or wound vacuums postoperatively.[47,48]

• *Immunodeficiency.* Immunodeficiency can occur for a variety of reasons, including chronic steroid use, malnutrition, chemotherapy, and human immunodeficiency virus infection. In an immunodeficient patient, the body's ability to fight infection is impaired.[29]

• *MRSA status.* Methicillin-resistant *Staphylococcus aureus* is an increasingly common nosocomial pathogen.[49] It is estimated that MRSA is responsible for more than 50% of hospital-acquired *S aureus* infections each year in the United States.[50] Hospital records should be reviewed for history of MRSA colonization or the need for repeat screening. Preoperative MRSA surveillance allows for the selection of appropriate prophylactic antibiotics and the use of extended decolonization protocols in MRSA-positive patients.[51]

• *Nutritional status.* Although there is no "gold standard" for effectively identifying nutritional status, it has been observed that well-nourished patients respond to and recover from surgery better than undernourished patients.[52] Malnourished patients have a significantly higher incidence of complications, increased mortality, longer length of inpatient stay, and higher total costs than well-nourished patients.[53–55] In a 2013 study, researchers used the Nutritional Risk Screening score to assess malnutrition in gynecologic patients and found that malnutrition occurs frequently, with 30.1% of patients in the surgery cohort at severe risk of malnutrition (Nutritional Risk Screening score of 3 or greater).[53] These data suggest that health care providers should pay attention to a patient's nutritional care before and after surgery.

• *Smoking status.* Postoperative healing complications occur significantly more often in smokers compared with nonsmokers and in former smokers compared with those who never smoked.[56] In a randomized, controlled trial conducted in 2003, Sørensen et al found that the wound-infection rate in smokers was 12%, compared with only 2% in never-smokers.[57] Their results further demonstrated that abstinence from smoking for as little as 4 weeks significantly reduced the rate of incisional wound infections.[57]

The "WASHING" mnemonic was designed by the authors of this article to aid in recalling the identified risk factors (Box 2).

Response (Every Case)

The *Response* domain outlines three key elements that should be used with every patient.

8. *Developing Intraoperative "Timeouts"*

Timeouts are mandated by the Joint Commission as part of the universal protocol before every surgical procedure.[18] These occur in the operating room before skin incision and confirm, among other items, the administration of antibiotic prophylaxis within the previous 60 minutes. These safety checklists by all members of the surgical team help to establish a culture of teamwork and aid in appropriately addressing factors that contribute to reducing the risk of surgical site infection.

9. *Reassessing Patient Risk*

Unanticipated intraoperative events may contribute to a change in risk and can be overlooked by surgeons as they focus on the technical aspects of the case. An intraoperative timeout, particularly at the end of the case (some-

W: Weight
A: Antibiotic-resistant skin flora, methicillin-resistant *Staphylococcus aureus*
S: Smoking cessation
H: Hygiene (skin preparation)
I: Immune deficiency status
N: Nutritional status
G: Glycemic control

Box 2. WASHING Mnemonic

times referred to as a "sign-out"), can help prevent these omissions. Appropriate intraoperative questions related to the risk of surgical site infection include the following:

- Was the surgery lengthy, with the duration extending beyond 2–3 hours? This may suggest the need to repeat the administration of antibiotics.
- Was the estimated blood loss for the hysterectomy in excess of 1,500 mL? This may suggest the need for a repeat dose of antibiotics.
- Were unanticipated surgical procedures performed that may increase the risk of surgical site contamination, such as a procedure involving the colon? This may suggest the need to extend antibiotic prophylaxis by adding metronidazole to the patient's preoperatively administered antibiotic.

10. Postoperative Care Instructions and Education for Women and Families

Preparation for discharge is a multipronged process and requires the provision of education and instructions to both the woman undergoing surgery and her family or other support persons. Patients and family members or support persons who are knowledgeable regarding postoperative care instructions and expectations as well as potential surgical complications, such as surgical site infections, are more empowered to seek medical care earlier to prevent additional complications. Instructions should be provided in the method in which the patient learns best and also should be tailored to a patient's literacy level.

Whenever possible, demonstration of proper wound care techniques should be provided; this assures that both patients and support persons are familiar and comfortable with the process. Similar to preoperative care, postoperative care instructions should be provided and should include information on:

- Proper care of the operative site
- Activity limitations such as stair climbing, exercise, driving, working, bathing
- Medications and supplies needed for home care
- Pain management, both pharmacologic and other comfort measures
- Home care resources
- Follow-up visits with health care provider and reason for follow-ups
- Signs and symptoms of surgical site infection such as redness and pain over surgical area, drainage from wound, or fever[58]

A prepared program with specific, consistent content and multiple approaches provides an opportune environment to assure patient learning. It has been demonstrated that patients have suffered needlessly owing to inadequate perioperative preparation and lack of information regarding their postoperative course, as indicated by reports of unexpected pain, fatigue, and inability to care for themselves.[11] Reinforcement of care instructions along the continuum, starting with the office visit and flowing through to the immediate perioperative period and into the postoperative period, prepares the patient for success. Phone call follow-up by the perioperative team 24–48 hours after discharge provides additional opportunities to reevaluate patient comprehension of discharge instructions, reinforce education, and allay patient anxiety.

Reporting and Systems Learning

The *Reporting and Systems Learning* domain contains five elements focusing on systems improvements that can be used to drive quality improvement in every facility.

11. Establish a Culture of Staff Huddles for High-Risk Patients

Communication failures are consistently cited as the leading root cause of sentinel events.[59] As discussed previously, the use of huddles, surgical timeouts, sign-outs, and checklists are strategies that should be implemented in the inpatient and outpatient setting to ensure appropriate and timely antibiotic administration and implementation of other measures aimed at reducing the incidence of surgical site infections.

Huddles are brief team meetings, intended to be less than 15 minutes in duration, in which the objectives for the day are expressed along with possible concerns and any newly emerging information.[60] Because there are actions that need to be taken by the surgical team[59,60] as well as by the office-based team (eg, counseling about the importance of euglycemia for diabetic patients, smoking cessation, preoperative antiseptic showering),[61] implementation of huddles with both the surgical team and the outpatient office staff may result in the best outcomes for patients.

Huddles have been shown to increase both the quantity and quality of information sharing and communication.[62–64] Specifically, the amount of time spent communicating decreases, but the amount of content communicated increases, resulting in greater staff satisfaction with the communication.[63,64] Implementation of huddles also has been shown to result in decreased errors such as wrong-site surgeries.[64] Over time, huddles can lead to increased accountability and sense of staff

empowerment.[62] Although daily huddles should be implemented, this does not negate the importance of a preoperative surgical timeout because cases could move from one room to another or operating room personnel could change during the day, resulting in the possibility of error if important information is not communicated among new team members.

12. Create System to Analyze and Report Surgical Site Infection Data

Process improvement strategies, such as the use of dashboards or scorecards, should be developed to analyze and report surgical site infection data.[65] Ideally, the system that is developed should be able to extract data on patient risk factors, surgical risk factors, and outcome data. Outcome data could be used for reporting relative to local and national benchmarks, goal setting, and tracking progress on quality-improvement initiatives.

The criteria used to define surgical site infections should be consistent with the Centers for Disease Control and Prevention's National Nosocomial Infections Surveillance criteria for defining surgical site infections discussed previously (ie, superficial incisional surgical site infection, deep incisional surgical site infection, or organ space surgical site infection).[61] Several methods are available to identify surgical site infection cases. Although direct observation and reporting would ensure the most accurate data, other strategies, such as screening microbiology reports, identification of patients with International Classification of Diseases, 10th Revision (ICD-10) codes consistent with surgical site infections, and identification of patients readmitted with wound infections, are alternative strategies. Other ascertainment methods, such as patient or health care provider surveys, may be prone to recall bias.

13. Monitor Outcomes and Process Metrics

Monitoring outcomes and process metrics is essential for identifying problems and enacting change. Because many patient, health care provider, and surgical factors can influence surgical site infections, collection of additional data will allow for risk stratification in reporting and analyzing outcomes (Box 3).

Two standardized methods for risk stratification for surgical site infection exist; however, this does not prohibit centers from adjusting for additional risk factors deemed to be important. The two commonly used methodologies for risk stratification of surgical site infection are the National Healthcare Safety Network index and the standardized infection ratio. The National Healthcare Safety Network risk index scores range from 0 to 3, where 0 represents the lowest risk and 3 represents the greatest risk. Three variables each contribute 1 point: American Society of Anesthesiologists physical status score greater than 3, contaminated or dirty wound classification, and procedure duration greater than the 175th percentile.[66] This model has poor predictive performance for many surgeries; therefore, new procedure-specific models have been constructed.[67] The second commonly used methodology for risk stratification is the standardized infection ratio. The standardized infection ratio methodology similarly accounts for patient- and procedure-related risk factors within each type of surgery (eg, patient age, wound class, duration of surgery).[68] The standardized infection ratio compares the number of infections that were observed at the hospital-, state-, or national-level with the number of predicted infections. If the ratio is less than one, fewer infections were observed than expected; values greater than one indicate that more infections were observed than were expected.[68]

Patient-level risk factors

- Obesity
- Diabetes mellitus
- Smoking status
- Steroid use
- Nutritional status
- American Society of Anesthesiologists Physical Status

Health care provider–level risk factors

- Adherence with hand-washing and use of proper surgical attire

Surgical risk factors

- Preoperative skin antisepsis
- Preoperative hair removal
- Operating room temperature
- Type of surgery
- Duration of surgery
- Insertion of foreign material
- Appropriate redosing of antibiotics (eg, owing to prolonged duration of surgery, excessive blood loss)

Box 3. Patient, Health Care Provider, and Surgical Data for Risk Stratification

Equally important to measurement and reporting of outcomes is the use of process measures. These allow for evaluation of adherence to guidelines and recommendations. Improvements in process measures may be seen before changes in outcomes are demonstrated depending on the case volume at a given center. At a minimum, performance with the percentage of patients that receive appropriate antibiotic prophylaxis, administration of the correct antibiotic agent, timing relative to surgery, and appropriate discontinuation of antibiotics postoperatively should be measured and reported. Additional metrics could include patient education on wound care and distribution of appropriate wound care discharge instructions.

A multidisciplinary review of surgical site infection data should be convened at regular intervals to review data on outcome measures and process adherence.

Surgeons, anesthesia providers, nurses, pharmacy staff, infectious disease specialists, and hospital leadership should be engaged in this review.

14. Collect and Share Physician-Specific Data

Surgical site infection data should be reported to physicians as part of a routine feedback and auditing process. In a systematic review on effective quality improvement strategies for promoting adherence to evidence-based preventive interventions for surgical site infections, Mauger et al found that audit and feedback resulted in improvements in professional practice.[69] If possible, risk-stratified data should be provided so as not to penalize health care providers who care for higher-risk patients. The frequency of this feedback should be determined by the hospital based on case volume to provide the most meaningful feedback to health care providers. A process for individual remediation should be in place in the event of consistent nonadherence with process measures.

15. Actively Monitor and Collect Data with Postdischarge Follow-up

Given the increase in outpatient surgery and the decrease in postoperative length of stay for patients who are admitted, it is possible that patients will not develop surgical site infections while in the hospital. Therefore, systems should be in place for outpatient reporting of surgical site infections. If the outpatient clinics use the same electronic health record system, electronic queries of that system may be able to extract diagnoses consistent with surgical site infections. If such a system does not exist, a method for reporting and documentation should be developed so that office staff can report surgical site infections to the hospital system for accurate tracking. Similarly, if a patient presents to an outpatient clinic and the surgery was performed at another hospital, a system should be implemented so that the information can be communicated to the primary hospital.

Discussion and Conclusion

The goal of this safety bundle is to reduce the frequency of surgical site infections. This bundle was formulated using a compilation of existing guidelines and evidenced-based recommendations that was then formatted for easy dissemination and rapid implementation. This bundle emphasizes the importance of teamwork among all disciplines and highlights the importance of shared responsibility of all team members to prevent surgical site infection. Foremost among these shared responsibilities is the relationship and communication between the surgeon and the anesthesia provider in ensuring that all surgical site infection prophylactic measures are in place. Some of these measures include antibiotic selection, administration, and re-administration; temperature regulation; and team-building and communication. Currently the recommended antibiotic regimens can be individualized by the surgeon based on the needs of the patient. Both the surgical team and the office-based staff have roles in optimizing surgical outcomes. It is important to empower all members of the team to identify any deviation from standardized procedures used to prevent surgical site infection without fear of repercussion. Coupled with this empowerment, the bundle stresses the importance of ownership by each team member in reducing surgical site infection through adherence to the recommendations and use of the resources outlined within the body of the bundle.

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