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Prevention of Surgical Site Infection: Beyond SCIP

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Surgical site infections (SSIs) are a leading cause of patient morbidity and mortality. Each SSI that occurs is associated with approximately seven to 10 additional postoperative hospital days,[1,2] and patients with SSIs have a two to 11 times higher risk of death compared to surgical patients without SSIs.[3,4] Surgical site infections have now emerged as the most common and most costly cause of health care–associated infection.[5,6] Thus, hospitals and health care providers must constantly pursue and improve adherence with evidence-based strategies for preventing these devastating infections.

Several core SSI prevention strategies have been promoted by the Surgical Care Improvement Project (SCIP), including the appropriate choice and timing of antimicrobial prophylaxis, avoiding shaving surgical site hair, maintaining perioperative patient normothermia, and controlling perioperative blood glucose.[7] During the past decade, many, if not most, providers associated with quality improvement and surgical improvement programs in the United States have become familiar with the SCIP recommendations. In fact, health care providers are placing great effort on improving staff member compliance with these recommendations because rates of performance on SCIP measures now affect hospital payment under the Centers for Medicare & Medicaid Services Value-Based Purchasing Program.[8,9] Compliance with some of the SCIP recommendations is now close to 100%; thus, some of these quality measures have been retired (eg, avoiding surgical site hair shaving).

If hospitals are near 100% compliance with some of the basic SCIP recommendations, yet SSIs still occur and harm patients, the question then becomes, “What else can be done?” This column will summarize several additional evidence-based strategies that go beyond SCIP recommendations to prevent SSIs: optimizing antimicrobial prophylaxis dosing, preparing the colon with mechanical bowel preparation and oral antibiotics, optimizing tissue oxygenation, and using a surgical safety checklist.

OPTIMIZE ANTIMICROBIAL PROPHYLAXIS DOSING

Ideally, the concentration of antibiotic in the patient’s tissue should be at its highest at the time of incision, the time when pathogenic organisms are most likely to be introduced into the surgical field. This ideal is, in fact, a central tenet behind the SCIP recommendation to

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administer the antimicrobial prophylaxis within 60 minutes of incision for most medications. Additionally, for an average patient weighing 70 kg during an average procedure of three hours or less, administration of the antibiotic within 60 minutes of incision ensures that the concentration of the antibiotic remains above the threshold needed to reduce the of risk of infection during the procedure.

The relationship between the administration of antimicrobial prophylaxis and effectiveness in reducing the risk of SSI can be conceptualized as a gas tank for a vehicle. That is, a driver "fills up the tank" of a vehicle at the beginning of a trip (ie, the time of incision) and the gas tank's level slowly decreases over time until, eventually, the vehicle runs out of gas, or in the case of surgical patients, enough antimicrobial concentration to prevent an SSI. In other words, standard dosing strategies ensure that there is enough antibiotic coverage (or gas in the tank) to safely make it through an average procedure for the average patient. Two specific scenarios, however, lead to risky situations in which there is inadequate antibiotic coverage: surgery on obese patients and prolonged surgery. Thus, two additional approaches are needed to optimize antimicrobial prophylaxis in certain patients and procedures.

Weight-Based Dosing of Perioperative Antibiotics

Obesity increases the risk of SSI twofold to sevenfold compared to healthy weight for several reasons.[10–12] Adipose tissue is poorly vascularized, and as a result, obese patients typically have decreased tissue oxygenation.[13,14] Because of this, lower concentrations of antibiotic in the blood and other tissues occur.[15,16] Surgery on obese patients also is technically challenging and creation of dead space (ie, an actual or potential cavity remaining after the closure of an incision that is not obliterated by operative technique) occurs regularly. Finally, typical doses of antimicrobial prophylaxis are not adequate to "fill up the tank" in obese patients because the volume of distribution is larger.

To address these issues, the most easily modifiable strategy is to adjust antimicrobial prophylaxis dosing based on patient weight.[17] This strategy effectively "tops off" the tank. For example, health care providers should increase antimicrobial prophylaxis to 2 g of cefazolin for patients weighing ≥ 80 kg and 3 g for patients weighing ≥ 120 kg.[18] Providers should administer vancomycin at 15 mg/kg, and gentamicin at 5 mg/kg. For morbidly obese patients receiving gentamicin, the weight used for dose calculation should be the patient's ideal weight plus 40% of their excess weight. Additional weight-based dosing recommendations can be found in the recently published "Clinical practice guidelines for antimicrobial prophylaxis in surgery."[18]

Re-dose Prophylactic Antimicrobials During Long Procedures

Surgical time correlates with risk of infection: the longer the operative time, the higher the risk of SSI. In a multicenter, prospective trial of 4,700 patients undergoing abdominal surgery, the risk of SSI was 6.3% for procedures lasting less than 60 minutes, 12.2% for procedures between one and two hours, and 28% for procedures lasting longer than two hours.[19] As a result, health care providers should re-dose prophylactic antimicrobials during long procedures (ie, more than three hours).[18] This strategy is analogous to a stop at a gas station on a long trip. In one study of 801 patients undergoing clean-contaminated procedures, patients with prolonged surgery (ie, more than three hours) had a lower rate of SSI when they received a second dose of cefazolin at approximately three hours after incision time compared to patients who did not receive a second dose (ie, risk of SSI was 1.3% versus 6.1%, $P < .01$).[20] In general, health care providers should re-dose prophylactic antibiotics at intervals of two half-lives of the medication measured from the time the preoperative dose was administered.

"In general, health care providers should re-dose prophylactic antibiotics at intervals of two half-lives of the medication measured from the time the preoperative dose was administered." For example, the half-life of cefazolin is approximately 1.5 to two hours. Thus, cefazolin should be re-dosed every three to four hours during a long procedure.

PREPARE THE COLON WITH MECHANICAL BOWEL PREPARATION AND ORAL ANTIBIOTICS

Historically, a great deal of controversy has colored the use of mechanical bowel preparations (ie, using laxatives to decrease the amount of stool in the colon) before colorectal surgery. Many thought the practice was unsafe while others thought it was standard of care. Some of this controversy likely was generated because of conflicting data in studies using different types of bowel preparations, some using oral antibiotics and some without. After 70 years and more than 180 randomized trials, it is now clear that mechanical bowel preparation alone does not reduce the risk of SSI.[21,22] Instead, the preponderance of data suggests that oral antibiotics should be combined with parenteral antibiotics.[23,24] Thus, the most effective approach for mechanical bowel preparation includes the use of a chemical preparation (eg, polyethylene glycol) combined with the administration of both oral and parenteral antibiotics.[21,23–27]

OPTIMIZE TISSUE OXYGENATION

Oxygen is required for appropriate wound healing and white blood cell functioning.[28–30] In fact, tissue hypoxia is a known risk factor for wound infection and dehiscence.[31] Thus, attempts to increase tissue oxygenation during an operative procedure may help prevent SSI. In fact, supplemental oxygenation, the practice of supplying the surgical patient with 80% FiO_2 (fraction of inspired oxygen) during and after surgery is effective at preventing SSI.[32–34] This strategy is most effective when combined with additional strategies to improve tissue oxygenation, including maintenance of normothermia and appropriate volume replacement.[32–34]

To date, seven randomized clinical trials have been published comparing the use of 80% FiO_2 with 30% to 35% FiO_2 in patients undergoing general anesthesia with intraoperative mechanical ventilation and postoperative oxygen delivered for two to six hours via a non-rebreathing mask.[32–38] Three trials in patients undergoing elective colorectal resection[32,33,37] and one each in open appendectomy[34] and total gastrectomy with esophagojejunal anastomosis[38] reported an approximately 40% decrease in the rate of SSI. Two trials in mixed surgical populations undergoing emergency or elective laparotomy for gastrointestinal, gynecologic, or urologic procedures reported different results.[35,36] One trial reported no difference,[35] while another, smaller trial reported an increase in SSIs.[36] In this study, the 80% FiO_2 group had a significantly higher proportion of patients with high body mass index (ie, > 30), higher blood loss, more crystalloid infused, and longer procedures. A meta-analysis of five of the above referenced studies, including the "negative" study, concluded that perioperative supplemental oxygen led to a relative risk reduction of 25% for SSI.[39]

USE A SURGICAL PATIENT SAFETY CHECKLIST

Checklists have emerged as an important quality improvement tool for ensuring that best practices are performed, and the surgical arena is no different. "Checklists have emerged as an important quality improvement tool for ensuring that best practices are performed; in the perioperative arena, use of the World Health Organization checklist improves surgical outcomes." The World Health Organization (WHO) created a 19-item surgical safety checklist to improve adherence with best practices.[40] Items on the checklist are separated into three areas: sign in, time out, and sign out. During the time out phase, for example, the surgical team confirms that prophylactic antibiotics were administered appropriately or that antibiotics were not indicated.

Use of the WHO checklist improves surgical outcomes. A multi-center quasi-experimental study conducted in eight countries demonstrated that use of the WHO checklist lead to a 50% decrease in rates of SSI and death.[41] These findings have been confirmed in subsequent single- and multi-center quasi-experimental studies.[42,43]

CONCLUSION

Most hospitals have achieved great successes in improving adherence to the basic quality measures recommended by SCIP. Yet, patients continue to have SSIs. Evidence-based strategies—optimizing antimicrobial prophylaxis dosing, preparing the colon with mechanical bowel preparation and oral antibiotics, optimizing tissue oxygenation, and using a surgical safety checklist—can help high performing hospitals and health care providers move beyond SCIP to ensure that they provide the best care possible to their surgical patients and decrease the rate of SSI.

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