Emerging Intraoperative Strategies for Reducing Surgical Site Infection Risk in Colorectal Surgery

What to Do When the Guidance Isn’t Clear

Summary

Given that approximately half of surgical site infections (SSIs) are preventable according to the Centers for Disease Control and Prevention (CDC), SSI rates continue to be high, particularly in colorectal surgeries. More focus is needed on what hospitals can do to enhance SSI prevention bundles with research, expert consensus, and innovative new approaches.

The risk of SSI is higher in colorectal operations due to the high levels of contamination that occur during these surgeries. Therefore, intraoperative infection control measures focused specifically on wound-edge contamination should be evaluated for inclusion in colorectal SSI bundles and programs.

This paper offers recommendations on two critical areas of SSI prevention:

- Making existing SSI bundles more effective in infection prevention and control through enhanced standardization

- Expanding SSI bundles to incorporate emerging infection prevention technologies and methods when zero preventable SSIs have not been achieved
Surgical Site Infection Risk in Colorectal Surgery

Experts estimate that up to 55% of all surgical site infections (SSI) are preventable.¹ This statistic is especially important for colorectal surgery patients who suffer a disproportionate number of surgical site infections. The average rate of all SSIs in the United States is 2%, which equates to 300,000 infected patients each year.² However, despite the best efforts of surgical teams, the SSI rate after colorectal procedures is much greater—between 15% and 30%.³ One contributing factor is that entry into the lumen of the colon, either planned or un-planned, often results in contamination of abdominal cavity and wound edges, increasing the risk of colorectal SSI.⁴ Another factor is that a lack of standardization in SSI prevention processes may add to the risk.⁵ In addition, we know that SSI prevention bundles are often limited to those measures supported by randomized controlled trials, despite falling short of the goal of zero preventable infections.⁶

Even among elective surgical procedures, colon surgery is associated with the highest rate of SSI.⁴ Globally this could become an even more significant problem in the future, as the percentage of people over the age of 65 is increasing, anticipated to grow from 6% (2000) to 16% by 2050. This is relevant because colorectal cancer requiring surgical intervention is the third most common cancer and advanced age is a risk factor.⁷

The Centers for Disease Control and Prevention (CDC), the American College of Surgeons (ACS), and the National Surgical Quality Improvement Program (NSQIP) categorize SSI based on the anatomic location of the infection: superficial incisional, deep incisional, and organ space.⁸⁻¹⁰ Superficial infections involve the skin and subcutaneous tissues, deep infections involve the muscle and fascia, and organ/space infections are in the abdominal cavity (after colorectal surgery). This paper will address risk factors associated with superficial and deep surgical infection after colorectal surgical procedures and strategies to mitigate that risk.

### THE PROBLEM

1. Colorectal SSI rates remain high
2. Contamination during the procedure contributes to high SSI
3. Lack of standardized prevention processes adds risk
4. Bundles limited to measures supported by randomized controlled trials despite falling short of goals

### Patient and Economic Impact of SSI after Colorectal Surgery

The average excess cost associated with a colorectal SSI (superficial, deep, and organ space combined) is estimated to be $17,325.¹¹ In addition, these infections require a longer length of hospital stay and confer a higher mortality risk.¹²⁻¹⁵ In one study of more than 500 patients, superficial SSI after colorectal surgery was associated with a 71.7% increase in initial hospital length of stay (7.9 vs. 4.6 days, P < 0.001).³ These infections can also result in increased readmission rates with associated secondary hospital stays. In a recent study of more than 10,000 colorectal surgery patients, the 30-day readmission rate was 11.4%, and the 90-day readmission rate was 23.3%. The mean readmission length of hospital stay was 8 days.¹⁶ Not as easily quantifiable is the patient suffering and family impact resulting from postoperative surgical infection.¹⁷

### THE CONSEQUENCES

SSIs are costly to the hospital and have significant impact on the patient’s quality of life.
Role of Intraoperative Wound-Edge Contamination in Superficial and Deep SSI after Colorectal Surgery

Wound-edge contamination is the primary predisposing factor for superficial and deep colorectal SSI, which is further amplified by the virulence of the contaminating microorganisms and any compromise of the patient’s host defenses.4

THE CONTAMINATION CULPRIT

Wound-edge contamination is the primary predisposing factor for incisional SSI in colorectal surgery

The greater the number of contaminating bacteria on the wound edges, the greater the probability of infection.4 In open, lap-assisted, robotic, and completely laparoscopic abdominal procedures, bacteria can easily be transferred to the wound edges from hollow viscera. Consequently, gram-negative bacilli (e.g., Escherichia coli) and anaerobes (e.g., Bacteroides fragilis) are reported as the most common pathogens causing colorectal SSI.18 There is, of course, an additional, much smaller risk from gram positives such S. aureus, which may be introduced from patient’s skin flora remaining after skin prep or from the surgical team.4

Enhancing SSI Prevention Specific to Colorectal Procedures

Standard SSI prevention efforts (typically applied in a bundle) to reduce the inoculum of bacteria that could cause infection after colorectal surgery cases include: appropriate surgical site skin preparation (reduces the risk of introducing bacteria at the time of incision), systemic prophylactic antibiotics (directed at bacteria that may contaminate the abdominal cavity and wound edges during a case), glucose control (to optimize leukocyte bactericidal activity), normothermia (to prevent triggering thermoregulatory vasoconstriction), use of mechanical bowel preparation in conjunction with the oral antibiotic bowel preparation (reduces the colonic bioburden, the source of bacteria which could result in wound-edge and visceral contamination because the bowel is intentionally opened as part of the planned operation), irrigation, and wound-edge protectors (reducing wound edge and visceral contamination during the surgical case).4,9,19,20,23–26 However, professional guidance to ensure a standardized approach is lacking for most of these SSI prevention elements.24–27 Additionally, guidance regarding application of emerging effective SSI prevention methods and technologies supported by less than randomized controlled studies – plus measures – is similarly lacking.

In the past decade, SSI prevention efforts have been focused on improving compliance with evidence-based practices, such as those from the Surgical Care Improvement Project (SCIP).3,19 Studies have demonstrated that improved outcomes can be achieved by applying these practices via a systematic approach or bundle.11,20–22 However, despite all efforts to date, the SSI rate for colorectal cases in most locations remains high. Consequently, it may be prudent to consider enhancement of existing SSI prevention bundle elements and/or addition of new evidence-based bundle elements for high-risk procedures such as colorectal.

THE CALL TO ACTION

Consider enhancement of existing SSI prevention bundle elements and/or addition of new evidence-based bundle elements for high risk procedures

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This paper will help to provide initial insight and recommendations regarding (1) standardization of key colorectal surgery SSI prevention bundle elements that are not clearly defined in published guidelines, and (2) introduction of innovative SSI prevention methods and technologies or “plus measures” for consideration when SSI prevention targets have not yet been achieved with the existing bundle.

**Standardization of Key Colorectal Surgery SSI Prevention Bundle Elements**

The following key elements are either done intraoperatively or are done preoperatively but have a direct impact on intraoperative contamination.

**Preoperative Oral Mechanical Bowel Preparation (OMBP) and Oral Antibiotics**

The recently published SSI Prevention Guidelines from the American College of Surgeons, World Health Organization, Society for Healthcare Epidemiology of America, and Wisconsin Public Health Council recommend the use OMBP followed by oral antibiotics before elective colorectal surgery. However, there is no agreement regarding the best protocol for bowel prep or the preferred type of oral antibiotic.9,28-31

Enhancing Standardization of OMBP and Oral Antibiotics

In the absence of a nationally recognized standard protocol for OMBP and oral antibiotics, at a minimum, it would be prudent to support a standardized approach among surgeons at a facility level. This may be best accomplished in collaboration among surgeon(s) with input from an Infectious Diseases physician specialist.

**Preoperative Surgical Skin Preparation**

Preoperative skin preparation begins at most locations with antiseptic patient bathing as supported by all recent SSI Prevention Guidelines except CDC.9,28-31 Adhering to a scientifically proven, standardized process for preoperative bathing with either chlorhexidine gluconate (CHG) liquid or CHG impregnated bathing cloths has been proven to result in skin surface concentrations of CHG that are sufficient to inhibit or kill gram-positive or gram-negative surgical wound pathogens (16.5μg/cm²).32

In addition to preoperative antiseptic bathing, surgical skin preparation involves the antimicrobial solution applied to the planned incision area in a prescribed manner. The quality of skin preparation products used in the operating room has improved over the years, however, the application process is still subject to human error. A dual-agent skin prep product (alcohol plus iodine or CHG) is recommended by all recent SSI prevention guidelines as the most effective.9,28-31 Studies focused on surgical skin preparation have reported that contaminants may remain after prep is completed, if not performed correctly or without the appropriate prep solutions.33,34
Enhancing Standardization of Preoperative Surgical Skin Preparation

- Ensure one of the following scientifically proven protocols for preoperative antiseptic bathing is provided to, and followed by, all colorectal patients:
  - Use a bottle containing 118 mL of 4% aqueous CHG for each of two showers: one the night before surgery, the second the morning of surgery. During each shower, pause for one minute after lathering and before rinsing.32
  - OR –
  - Use a total of six CHG-impregnated cloths: one for the neck and chest, wiping side to side including under breasts; one for the back; one for each arm and underarm; and one for each leg and groin. Allow to air dry and do not rinse off.35

- Validate surgical skin preparation application competency for nurses and/or technicians who are responsible for performing it.36

- Consider simulation as the method of competency training, which has been proven to be effective for retention of knowledge.37

Wound-Edge Protectors

Wound-edge protectors are designed with a plastic sheath attached to either a single ring or two rings, which secure the device and isolate the wound edges. This device additionally may provide retraction of the incision, improving visualization. These devices are intended to reduce wound-edge contamination during abdominal surgical procedures, such as colorectal.28 Multiple recently published peer reviewed SSI Prevention guidelines have endorsed the benefit of wound-edge protectors for SSI risk reduction.9,28-31 In some studies, the SSI rate with a single-ring wound-edge protector device has been reported to be as much as twice the rate compared to when a double-ring device was used.28 Regardless of design, if the wound-edge protector is not inserted or removed correctly, injury and wound-edge contamination can result.28

Enhancing Standardized Use of Wound Edge Protectors

- Use only double-ring wound-edge protection devices.28

- Ensure that surgeons receive training on the use of wound-edge protectors, including the correct process for insertion and removal, to avoid wound-edge injury and contamination.28

Intraoperative Surgical Irrigation

Irrigation of wound edges and the abdominal cavity is done to remove contaminants, dead or damaged tissue, and wound exudate. As such, it has been suggested to be useful in reducing SSI risk.23

Among the most recent peer reviewed SSI prevention guidelines, there is no consensus on the topic of surgical irrigation.8,9,28,30 As a result, there is great inconsistency with regard to the three primary irrigation variables (delivery method, volume, and solution additives), but there is an increasing body of evidence suggesting the benefit of various irrigation methods in reducing contamination/SSI risk.23,27,39 It is important to evaluate different irrigation methods individually as opposed to as a heterogeneous group, since certain methods may show benefit more than others.

Enhancing Standardization of Intraoperative Surgical Irrigation

- Throughout the colorectal case, use sterile, normal saline for irrigation of abdominal cavity and wound edges to remove contaminants and debris.27

- At the end of the colorectal surgical case, prior to closure, consider trialing the use of an antiseptic irrigation solution applied to the abdominal cavity, with a one-minute pause after application, followed by rinsing to eliminate any remaining contaminants in the abdominal cavity (e.g., dilute povidone iodine and 0.05% CHG).40-43
Introduction of Product Innovations or Plus Measures

Innovation is important in advancing the efforts of surgical infection prevention programs. However, implementation of innovation by surgeons and other clinicians is often less than optimal. Regulatory and public focus on reducing infection rates and making healthcare safer provide a lever to support engagement of clinicians in considering innovations in surgical infection prevention. Infection Prevention professionals can play major roles in this translation via implementation science.44

Addition of Beyond the SSI Prevention Bundle

“Plus” Elements

Consider addition of the following innovations during expansion of colorectal SSI prevention bundles when zero preventable infections have not been achieved with existing methods:

- Use of innovative sterile 0.05% CHG surgical irrigation solution at the end of colorectal cases, allowing one minute for antimicrobial effect prior to rinsing out, in order to inactivate contaminants in the abdominal cavity prior to closing.45

- Use of innovative device that combines wound-edge protection and irrigation, thereby supporting a standardized approach to both.46,47

DEFINITION OF A PLUS MEASURE

Infection prevention practices and products that are supported by less than category 1 level evidence, which can be considered when there is no associated risk to the patient, and to support the drive to zero sustained preventable infections.

Conclusions

Improving the overall reliability of complex systems has been an approach used effectively in manufacturing and airline industries to improve safety and outcomes. Applying this same reliability principle to health care has been an approach that has succeeded in reducing “defects” in care or care processes including infections, increasing the consistency with which appropriate care is delivered, and improving outcomes.48

Despite the best prevention efforts, surgical infection after colorectal procedures remains on average between 15% and 30%. This results in largely preventable excess costs to health care and suffering of patients and families. It is time to consider enhancing standardized application of existing SSI prevention standards with inclusion of new technologies.

The primary variable responsible for superficial and deep surgical infection in colorectal cases is contamination of wound edges. If the proven principle of reliable design (i.e., standardization) was applied to reduce wound-edge contamination, the result could be improved consistency of high quality care and reduced incidence of colorectal SSI. In addition, until zero preventable colorectal SSI is achieved, expansion of SSI prevention bundles should be considered.

CONCLUSIONS

1. It is time to consider enhancing SSI Prevention with inclusion of new technologies

2. Until sustained zero preventable colorectal SSI is achieved, expansion of bundles should be considered
About the Author

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References


