

Identifying the Risk Factors for Postoperative Surgical Site Infections Following Abdominal Surgery and Improving Their Prevention

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Abstract

Surgical site infection (SSI) remains one of the most frequent and consequential complications of abdominal surgery. It prolongs hospitalization, raises cost and mortality, and is closely linked to the emergence of antimicrobial-resistant organisms. This review synthesizes current evidence to identify the main patient-, procedure- and postoperative-related risk factors for SSI after abdominal operations, and to outline an evidence-based, bundle approach to prevention. Abdominal procedures carry an intrinsically high risk because the incision crosses a microbiologically contaminated visceral tract. Recognizing modifiable factors, such as perioperative hyperglycemia, smoking, obesity, malnutrition, prolonged operations, hypothermia, inadequate antibiotic prophylaxis and unnecessary drains, allows them to be targeted. Implementation of a structured prevention bundle substantially reduces SSI rates, and stopping prophylactic antibiotics after 24 hours directly addresses the antibiotic-resistance challenge that makes SSI a leading contemporary surgical problem.

Keywords: Surgical site infection, abdominal surgery, risk factors, antibiotic prophylaxis, prevention bundle, antimicrobial resistance.

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1. Introduction

Surgical site infection is defined by the U.S. Centers for Disease Control and Prevention (CDC) and the National Healthcare Safety Network (NHSN) as an infection that occurs within 30 days of an operation, or within one year when a prosthetic implant remains, and that involves the incision or the deep tissues manipulated during the procedure. SSIs are among the most common healthcare-associated infections worldwide and are a sentinel marker of surgical quality. They are grouped as superficial incisional (skin and subcutaneous tissue), deep incisional (fascia and muscle layers), and organ or space infections, such as an intra-abdominal abscess, anastomotic leak or

peritonitis.

The burden is substantial. The prospective international GlobalSurg cohort reported SSI in 12.3% of patients after gastrointestinal surgery, with markedly higher rates in low- and middle-income countries than in high-income settings. Overall, SSI rates can reach up to 20% in resource-limited environments, compared with roughly 2 to 5% in high-income countries. In the United States alone, SSIs contribute to more than 400,000 extra hospital days and additional costs on the order of US\$10 billion each year. Beyond cost, deep and organ or space SSIs after abdominal surgery are associated with reoperation, prolonged intensive care, sepsis and increased mortality.

Abdominal operations deserve particular attention because the incision routinely enters the gastrointestinal tract, exposing the wound to endogenous enteric flora such as gram-negative bacilli, enterococci and anaerobes. This review focuses on abdominal surgery and addresses two complementary questions: which risk factors should be identified before and during the perioperative period, and how their prevention can be improved through a structured, evidence-based strategy. The link between SSI and antimicrobial-resistant organisms is emphasized throughout.

2. Definition, Classification and Baseline Risk

Anticipating SSI risk begins with classifying the wound. The traditional four-tier system stratifies operations from class I (clean, with no inflammation and no entry into the respiratory, gastrointestinal or genitourinary tract), through

class II (clean-contaminated, for example uncomplicated entry into the gastrointestinal tract with minimal spillage), class III (contaminated, for example fresh trauma, gross enteric spillage or a major break in sterile technique), to class IV (dirty-infected, with pre-existing clinical infection, a perforated viscus or devitalized tissue).

The classic five-year prospective study of more than 23,000 surgical wounds by Cruse and Foord demonstrated a stepwise increase in infection with worsening contamination: around 1% for clean wounds, 7 to 9% for clean-contaminated wounds, about 20% for contaminated wounds, and up to 40% for dirty-infected wounds. In abdominal surgery, a clean laparotomy therefore carries a fundamentally lower baseline risk than emergency resection for perforated diverticulitis, and preventive measures must be calibrated to this underlying contamination level. Figure 1 shows the abdominal wall layers that may be involved.

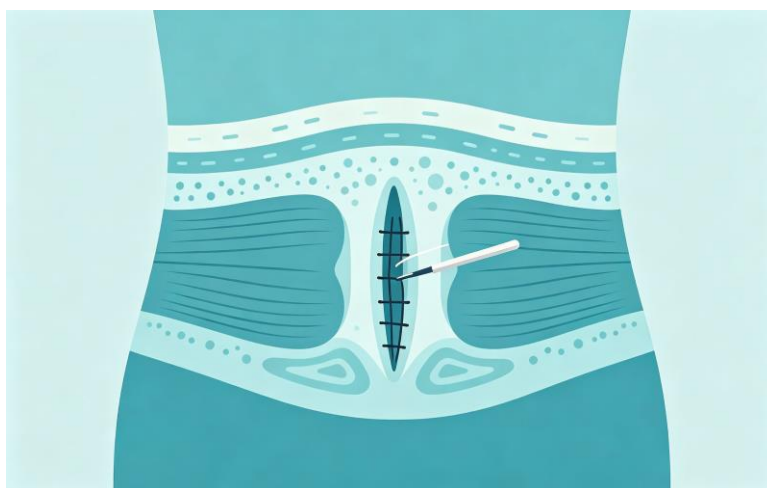


Figure 1. Schematic cross-section of the abdominal wall. SSI may involve superficial layers, the deep fascial and muscle layers, or the intra-abdominal organ or space.

3. Risk Factors for SSI after Abdominal Surgery

Risk factors are conventionally grouped into those relating to the patient, the procedure, and the postoperative or systemic period. A practical distinction is between modifiable and non-modifiable factors, because only the former can be acted upon.

3.1 Patient-related factors

Extremes of age, in the very young and the elderly, confer higher infection risk due to immature or declining immune function. Obesity is an independent and well-recognized risk factor: adipose tissue is poorly perfused, impairs surgical exposure, prolongs operation time and is prone to dead space and hematoma formation, all of which favor

bacterial proliferation. Diabetes mellitus and, importantly, perioperative hyperglycemia in both diabetic and non-diabetic patients are strongly associated with SSI, because elevated glucose impairs neutrophil function and wound healing. Smoking causes vasoconstriction and tissue hypoxia and raises the risk of wound complications. Malnutrition and hypoalbuminemia compromise collagen deposition and host defense, while immunosuppression, whether from corticosteroids, chemotherapy, organ transplantation or chronic illness, blunts the response to contamination. An elevated American Society of Anesthesiologists (ASA) grade summarizes cumulative patient frailty and is a robust predictor. Preoperative colonization with *Staphylococcus aureus*, particularly methicillin-resistant *S. aureus* (MRSA), further raises the

risk.

3.2 Procedure-related factors

The degree of wound contamination and the wound class is the dominant procedural determinant. Emergency surgery removes the opportunity for preoperative optimization and is associated with higher SSI rates. Prolonged operative time is independently associated with SSI, partly because it reflects technical difficulty, and partly because the duration of tissue exposure, the decay of antibiotic tissue levels and the magnitude of the surgical insult all increase with time. Operations extending beyond roughly two half-lives of the prophylactic agent require re-dosing. Excessive tissue trauma, aggressive electrocautery, imperfect hemostasis with hematoma or seroma, and failure to obliterate dead space create a culture medium for bacteria. Major intraoperative blood loss and allogeneic transfusion cause

immunomodulation. Finally, the use of surgical drains, and in particular drains that exit through the operative incision rather than through a separate stab wound, provides a pathway for skin flora to colonize the deep wound.

3.3 Postoperative and systemic factors

The postoperative period remains a key opportunity for prevention. Perioperative hypothermia impairs wound healing and vasoconstricts peripheral tissues, and its avoidance reduces SSI. Uncontrolled hyperglycemia after surgery continues to drive risk beyond the intraoperative phase, and hypoxia impairs bacterial clearance. Inadequate wound care, prolonged drainage and, most importantly, an unrecognized or inadequately drained anastomotic leak convert a contaminated wound into a deep organ or space infection.

Table 1. Major risk factors for SSI after abdominal surgery and their modifiability.

Risk factor	Category	Modifiable?
Age extremes, high ASA grade	Patient	No, assess and risk-stratify
Obesity / increased BMI	Patient	Partly, prehabilitation
Perioperative hyperglycemia	Patient/systemic	Yes, glycemic control
Smoking	Patient	Yes, stop at least 4 weeks before
Malnutrition / hypoalbuminemia	Patient	Yes, nutritional support
Immunosuppression / steroids	Patient	Partly, optimize
MRSA / S. aureus colonization	Patient	Yes, decolonization
High wound class, gross contamination	Procedure	Partly, technique and timing
Emergency surgery	Procedure	No, optimize resuscitation
Prolonged operative duration	Procedure	Partly, efficiency
Tissue trauma, hematoma, dead space	Procedure	Yes, surgical technique
Blood loss / transfusion	Procedure	Partly
Drains through the incision	Procedure	Yes, separate site and early removal
Perioperative hypothermia	Systemic	Yes, warming
Postoperative hyperglycemia / hypoxia	Postoperative	Yes
Undrained anastomotic leak	Postoperative	Yes, early recognition

4. Improving Prevention: The Structured SSI Bundle

Because no single intervention eliminates SSI, current guidelines, including the CDC 2017 guideline and the World Health Organization (WHO) global guidelines, recommend a bundle of evidence-based measures applied across the preoperative, intraoperative and postoperative phases. Bundles work because they address multiple mechanisms at once and are embedded in routine practice through checklists and audit.

4.1 Preoperative measures

Patient optimization targets the modifiable patient factors:

achieving acceptable glycemic control, initiating smoking cessation ideally at least four weeks before elective surgery, correcting nutritional deficits and treating active remote infections. Preoperative bathing with chlorhexidine gluconate reduces skin bacterial load. Hair, when it interferes with the operation, should be removed by clipping immediately before the procedure, never by shaving, which causes micro-abrasions that are colonized by skin flora. Identified MRSA carriers may undergo decolonization. Most importantly, prophylactic antibiotics must be administered within 60 minutes of the incision, or within 120 minutes for vancomycin or fluoroquinolones, so that adequate tissue concentrations are present when contamination occurs.

4.2 Intraoperative measures

The choice of antibiotic should match the expected flora. For abdominal and gastrointestinal procedures, a second-generation cephalosporin such as cefuroxime or cefoxitin is standard, and for colorectal surgery anaerobic coverage with metronidazole is added. Doses must be re-given for prolonged operations and after major blood loss, which dilutes and clears the drug. The WHO and CDC emphasize

maintaining normothermia with forced-air warming, controlling perioperative blood glucose, for which a practical target range is around 6.1 to 8.3 mmol per L, providing supplemental oxygen, and preparing the skin with an alcohol-based antiseptic such as chlorhexidine-alcohol. Meticulous hemostasis, avoidance of unnecessary tissue trauma, obliteration of dead space, use of an incision protector and a gentle, atraumatic technique remain the foundation of surgical prevention.



Figure 2. The prevention bundle acts as a shield, blocking bacteria from establishing a wound infection across the perioperative period.

4.3 Postoperative measures

Glycemic control should continue after surgery. The wound should be kept clean and dry, and drains should exit through a separate stab wound and be removed as early as clinically feasible, often within 24 to 48 hours when no longer required. Critically, the CDC 2017 guideline recommends

against extending prophylactic antibiotics beyond 24 hours after incision closure, even in the presence of a drain, because prolonged prophylaxis does not reduce SSI further and increases selection pressure for resistant organisms. Suspected infection should be confirmed with appropriate cultures before therapeutic antibiotics are escalated.

Table 2. Core components of an abdominal SSI prevention bundle by phase.

Phase	Evidence-based interventions
Preoperative	Optimize glucose and nutrition; stop smoking at least 4 weeks before; chlorhexidine bath; clip rather than shave hair; decolonize MRSA; give prophylaxis within 60 min of incision.
Intraoperative	Agent matching enteric flora, with anaerobic coverage as needed; re-give doses for long procedures or large blood loss; maintain normothermia; control glucose around 6.1 to 8.3 mmol per L; give supplemental oxygen; alcohol-based skin prep; atraumatic technique and hemostasis; use an incision protector.
Postoperative	Continue glycemic control; keep wound clean and dry; drains via a separate site and remove early; stop prophylaxis by 24 hours; obtain cultures before escalating therapy; recognize anastomotic leak promptly.

5. SSI and Antimicrobial Resistance

The link between SSI and antibiotic resistance is bidirectional and is central to the current surgical challenge.

First, the pathogens recovered from abdominal SSIs increasingly include resistant organisms. Among hospital-associated intra-abdominal infections, extended-spectrum

beta-lactamase (ESBL)-producing Enterobacterales, carbapenem-resistant organisms, *Pseudomonas aeruginosa*, *Acinetobacter baumannii*, MRSA and vancomycin-resistant enterococci are encountered with growing frequency, which limits treatment options. Second, and more actionable, repeated and prolonged exposure to prophylactic and empiric antibiotics is itself a major driver of resistance. The common practice of continuing prophylaxis for days after abdominal surgery offers no added protection against SSI but systematically selects for resistant strains and predisposes to *Clostridioides difficile* infection.

This is why preventing SSI is simultaneously an antimicrobial-stewardship intervention. Each avoided SSI is an avoided episode of broad-spectrum therapy, and each correctly timed, appropriately narrow, 24-hour prophylactic course reduces the resistance pressure in the hospital. Surveillance cultures and local antibiograms should guide empiric choices, and culture-directed de-escalation should

follow whenever an SSI does occur.

6. Implementation and Quality Improvement

Translating these measures into lower SSI rates requires more than guidelines. Successful programs embed the bundle in a surgical safety checklist, assign accountability, and measure performance through prospective surveillance using standardized NHSN or WHO definitions, including follow-up after discharge, because many superficial SSIs present after the patient leaves hospital. Regular audit with feedback to surgical teams, multidisciplinary infection-prevention rounds and attention to adherence, particularly to antibiotic timing and drain management, sustain the gains. In low-resource settings, where the SSI burden is highest, low-cost measures such as timely prophylaxis, basic asepsis, normothermia and glycemic awareness deliver disproportionate benefit.



Figure 3. A coordinated, sterile surgical team is central to delivering SSI prevention measures consistently across every case.

7. Conclusion

SSI after abdominal surgery is a predictable, multifactorial complication whose risk can be identified and substantially reduced. Recognition of modifiable patient factors such as hyperglycemia, smoking, obesity and malnutrition, of procedure factors such as wound class, operative time, drains and surgical technique, and of systemic factors such as hypothermia and ongoing contamination, allows them to be proactively managed. Applying a bundled, guideline-concordant strategy of patient prehabilitation, timely and appropriate antibiotic prophylaxis, maintenance of normothermia and euglycemia, atraumatic technique and early drain removal lowers SSI incidence. Crucially, stopping prophylactic antibiotics at 24 hours aligns SSI

prevention with the fight against antimicrobial resistance, making infection control and stewardship inseparable goals of modern abdominal surgery.

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