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# Risk Factors and Key Principles for Prevention of Surgical Site Infections

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## Abstract

Surgical site infections are one of the most important causes of healthcare-associated infections (HCAIs). They are associated with morbidity and possibly in part as a factor in associated postoperative mortality if present. Thus, it is important to recognize different SSIs and that they can vary from trivial wounds to a life-threatening condition. There are multiple risk factors contributing to the development of SSIs and guidelines to combat and decrease the possibility of the occurrence of such events through proper implementation.

**Keywords:** surgical site infections, hospital associated infections, criteria, classification, guidelines

## 1. Introduction

Infections occurring in the wound of an invasive surgical procedure are generally referred to as surgical site infections (SSIs), and they continue to be a common complication of surgical procedures despite advances in infection control practices.

This infection is a result of several factors that if combined would increase the risk of SSI together with the fact that the population is aging with longer average life expectancy meaning that not only the number of operations are likely to increase but also the SSI risk index for an aging population will be higher. Other clinical outcomes of SSIs include poor scars that are cosmetically unacceptable, such as those that are spreading, hypertrophic, or keloid; persistent pain and itching; and restriction of movement, particularly when over joints and have a significant impact on emotional well-being.

Given already the high economic cost of surgery, SSI will only burden the health system by increasing hospital stay, antibiotic intake, and other associated cost.

In this chapter we will briefly go through the pathogenesis and risk factors for SSI and guidelines to decrease their incidence.

## 2. Local events occurring on surgical incision

Most surgical wounds are contaminated by bacteria, yet infection will only develop in minority. As in the majority, innate host defenses will efficiently eliminate contaminants at the surgical site. This is besides other factors that interplay to give rise to a SSI including the inoculum of bacteria and its virulence and adjuvant microenvironment effects.

So what happens with the creation of the surgical incision through the skin and into subcutaneous tissues?

- A. First, of course, there will be platelet and coagulation factor activation as part of hemostasis mechanisms, and this also marks the beginning of the inflammatory process.
- B. Mast cells and complement proteins are activated, and bradykinin is produced from its precursors. The net effect of these factors is the production of non-specific chemoattractant signals and chemokine signals that “draw” variable leukocyte populations into the area of incision.
- C. Also we get vasodilation and increased local blood flow at the site of the incision. Yet blood flow slows down in preparation for margination of phagocytes.
- D. So we have increased vascular permeability and local vasodilation leading to edema fluid and increased space between endothelial cells, i.e., permeability, giving phagocytic access to the incised damaged tissue.
- E. The increased vascular permeability provides phagocytic access to the injured soft tissue, while edema provides aqueous conduits for the navigation of these phagocytes through the normally condensed extracellular tissues.
- F. Thus, this inflammatory process occurring at the site of injury is crucial for mobilization of phagocytes instantly into the incisional wound before significant intraoperative contamination occurs giving the patient an advantage against infection [1, 2].

### **3. Risk factors**

Despite of efficient decontamination and antisepsis, bacteria may still enter the wound from the OR environment or instruments or surgical staff or from patients skin. The largest inoculum of bacteria was found to occur with operations involving a body structure heavily colonized by bacteria (bowel). Substantial numbers of bacteria are also present in the stomach of older patients who have hypo- or achlorhydria. Significant concentrations of bacteria are encountered in the biliary tract when patients are over 70 years of age or have obstructive jaundice, common bile duct stones, or acute cholecystitis [3]. Procedures involving the female genital tract will encounter  $10^6$ – $10^7$  bacteria/mL. Procedures that enter into the oropharynx, lung, or urinary tract will have significant contaminants depending upon the duration and types of disease that are responsible for the operation. Notably, SSIs are generally the consequence of intraoperative contamination and seldom result from bacterial contamination from distant blood-borne seeding of the wound site during the postoperative period.

The larger the inoculum of bacterial contamination, the greater the probability of infection as the outcome. There are other factors that make a given bacterial inoculum to result in infection in a patient, while a similar inoculum of contamination in other patients has no such outcome. These are the local environment of the surgical site and the integrity of host defense of the patient. These factors include but not limited to surgical site hematoma, necrotic tissue from overuse of electrocautery, the presence of foreign bodies (e.g., sutures,

particularly braided silk and other permanent braided suture materials) in the surgical site, dead space management, and manner of handling soft tissue and organs are all contributors to SSI. These are technical issues that are generally not covered in published guidelines but are of great significance in the prevention of infection [4].

Another determinant contributing to SSI is the virulence of the bacterial contaminant. The more virulent the bacterial contaminant, the greater the probability of infection. Coagulase-positive staphylococci require a smaller inoculum than the coagulase-negative species. Virulent strains of *Clostridium perfringens* or group A streptococci require only a small inoculum to cause severe necrotizing infection. *Bacteroides fragilis* and other *Bacteroides* species are ordinarily organisms of minimal virulence as solitary pathogens, but when combined with other oxygen-consuming organisms, they will result in microbial synergism and cause very significant infection following operations of the colon or female genital tract [5]. The virulence of the bacteria represents an intrinsic variable influenced by the surgery site and bacteria colonizing the patient and cannot easily be controlled by preventive strategies.

Another factor to consider is the integrity of host defenses as acquired impairment of host responses is objectively related to increased rates of SSI, as in the case of chronic illnesses, malnutrition, hyperglycemia, and conditions associated with prolonged intake of corticosteroids and other infection at locations remote from the surgical.

Thus it is important to collect data on different types of risk factors in order to analyze SSI outcomes, to identify high-risk patients, and to control for differences in the patient level risk; this is done through surveillance. Important data to be collected for all patients are at least age; sex; type of surgical procedure, whether elective or emergency surgery; the American Society of Anesthesiologists (ASA) score; timing and choice of antimicrobial prophylaxis; duration of the operation; and wound contamination class [6].

#### 4. Important classifications

SSI can be classified according to the degree of microbiological contagion; this classification system is an adaptation of the American College of Surgeons wound classification scheme [7].

Wounds are divided into four classes:

**Clean:** An operative wound in which no infection and no inflammation is encountered, and the respiratory, alimentary, genital, or uninfected urinary tracts are not involved and are primarily closed.

**Clean-contaminated:** These are operative wounds that involve the respiratory, alimentary, genital, or urinary tracts but under controlled conditions and without unusual contamination. This category includes operations involving the biliary tract, vagina, appendix, and oropharynx.

**Contaminated:** These include, besides open, fresh, accidental wounds, operations with major breaks in sterile technique as in open cardiac massage or spillage from the gastrointestinal tract and incisions in acute inflamed tissues, including necrotic tissue without evidence of purulent drainage as dry gangrene.

**Dirty or infected:** This includes wounds with retained devitalized tissue and those with existing clinical infection or visceral perforation. In this group, it is suggested that the organisms causing postoperative infection were present in the operative field before the operation.

## **5. What are surgical site infection criteria?**

According to the CDC [7], SSI is classified into:

1. Superficial
2. Deep
3. Organ/space

### **5.1 Superficial surgical site infection**

Infection occurring within 30 days after any operative procedure and only the skin and subcutaneous tissue are involved must be associated with at least one of the following:

- Purulent drainage from the superficial incision, with or without culture testing
- Isolated organisms from an aseptically obtained specimen
- At least one of the following signs or symptoms: pain or tenderness, localized swelling, erythema, or heat and superficial incision deliberately opened by a surgeon
- Diagnosis of a superficial incisional SSI by the involved clinician

### **5.2 Deep incisional SSI**

Infection involves deep soft tissues of the incision as fascial and muscle layers and occurs within 30 or 90 days after the operative procedure and must be associated with at least one of the following:

- Purulent drainage from the incision but not from the organ or space involved
- Isolated organisms from an aseptically obtained specimen
- Dehiscence or deliberate opening or aspiration by the surgeon from the deep incision when the patient has at least one of the following: fever greater than 100.4°F, localized pain, or edema, unless culture is negative
- An abscess or other evidence of infection involving the deep incision that is detected during anatomical or histopathologic exam or imaging

### **5.3 Organ/space SSI**

It involves any part of the body deeper than the fascial/muscle layers, that is opened or manipulated during the operative procedure, and infection occurs within 30 or 90 days after the operation and must be associated with at least one of the following:

- Purulent drainage from a drain that is placed into the organ/space
- Organisms identified from fluid or tissue in the organ/space
- Abscess or other evidence of infection involving the deep incision that is found during examination of incision, reoperation, or pathologic or radiologic exam

## 6. SSI prevention guideline

- A. In late 2016, the World Health Organization (WHO) provided guidelines offering ways to stop surgical infections including evidence-based recommendations, addressing the increasing burden of healthcare-associated infections on both patients and healthcare systems. They are suitable for any country and can be locally adapted [8].
- B. In May 2017, the Centers for Disease Control and Prevention's (CDC) Healthcare Infection Control Practices Advisory Committee (HICPAC) published its Guideline for the Prevention of Surgical Site Infection, 2017, in the journal JAMA Surgery. Which also included evidence-based recommendations for the prevention of SSIs [9].
- C. The Association of periOperative Registered Nurses (AORN) has published the 2018 Guidelines for Perioperative Practice with five updated guidelines, as well as a completely new guideline that addresses team communication. Guidelines for Perioperative Practice, published each January, is a collection of 32 guidelines that provide evidence-based recommendations to deliver safe perioperative patient care and achieve workplace safety. The AORN's Guidelines for Perioperative Practice is divided into five main topic areas: Aseptic Practice, Equipment and Product Safety, Patient and Work Safety, Patient Care, and Sterilization and Disinfection [10].

## 7. Key recommendations in guidelines

### i. Preoperative bathing

It is considered a good practice to advise patients to bathe or shower (full body) prior to surgery, with either plain soap or an antimicrobial soap on at least the night before the operative day.

ii. For patients undergoing cardiothoracic and orthopedic surgery with known nasal carriage of *S. aureus*, decolonization with mupirocin 2% ointment with or without CHG body wash for the prevention infection in nasal carriers is recommended.

iii. Administer preoperative surgical antibiotic prophylaxis (SAP) prior to the surgical incision when indicated (based on the type of operation, published clinical practice guidelines and while considering the half-life of the antibiotic, such that a bactericidal concentration of the agents is established in the serum and tissues when the incision is made). Topical antimicrobial agents should not be applied to the surgical incision.

iv. As for postoperative antimicrobial prophylaxis in clean and clean-contaminated procedures, there is no need for additional antimicrobial prophylaxis doses after the surgical incision is closed in the operating room, even in the presence of a drain.

v. Hair removal in patients undergoing any surgical procedure should either not be removed or, if necessary, should be removed with a clipper, since shaving is discouraged, whether preoperatively or in the OR.

- vi. Performing surgical site skin preparation using an alcohol-based antiseptic solution is recommended unless contraindicated.
- vii. Surgical hand preparation to be performed by scrubbing with either a suitable antimicrobial soap and water or using a suitable alcohol-based handrub before donning sterile gloves.
- viii. Normothermia (i.e., a perioperative normal body temperature) to be maintained for all patients, in the OR and during the surgical procedure for reducing SSI.

However no randomized controlled trials evaluated methods to achieve and maintain normothermia and identified the lower limit of normothermia or the optimal timing and duration of normothermia for the prevention of SSI.

- ix. Sterile drapes and gowns, either disposable or reusable woven drapes and gowns, must be used during surgical operations for the purpose of preventing SSI. On the other hand, the use of plastic adhesive incise drapes for preventing SSI was discouraged.
- x. Wound protector devices were considered in clean-contaminated, contaminated, and dirty abdominal surgical procedures for the purpose of reducing the rate of SSI.
- xi. Irrigation of incisional wound using saline before closure for preventing SSI was neither recommended for or against as no enough evidence were present for justification. However the use of an aqueous PVP-I solution for the irrigation of incisional wound before closure in clean and clean-contaminated wounds for the purpose of preventing SSI was recommended. While antibiotic incisional wound irrigation was recommended against, CDC considers intra-operative irrigation of deep or subcutaneous tissues with aqueous iodophor solution for the prevention of SSI but stated that for contaminated or dirty abdominal procedures, it is not necessary.

xii. Antimicrobial triclosan-coated sutures for the purpose of reducing the risk of SSI, independent of the type of surgery, were suggested.

xiii. Perioperative glycemic control implementation using blood glucose target levels less than 200 mg/dL in patients with and without diabetes is recommended.

xiv. Regarding postoperative phase, there are fewer recommendations identified across the guidelines in relation to wound care. For example, the WHO (2016) guidelines states: “The panel suggests not using any type of advanced dressing over a standard dressing on primarily closed surgical wounds for the purpose of preventing SSI.”

xv. Team communication: AORN’s Guidelines are the first evidence-based guideline to tackle the issue of effective communication in the perioperative environment which is essential for accurate transfer of patient information. The Editor in chief of AORN’s Guidelines for Perioperative Practice stated that “Every AORN guideline recommends team involvement and shared communication with all stakeholders on the perioperative team, yet research still identifies

ineffective team communication as a common cause of adverse events,” and that “Understanding the evidence supporting strategies to strengthen team communication is critical for teams to successfully implement all AORN guidelines for safe perioperative care.”

## **8. Surveillance**

An effective infection prevention and control (IPC) program must not only apply measures and guidelines to avoid infections but should also monitor the outcome through surveillance. Which is defined as “the ongoing, systematic collection, analysis, interpretation and evaluation of health data closely integrated with the timely dissemination of these data to those who need it” [11].

## **9. Guideline implementation in reality**

It is important that guidelines can be adapted with relative flexibility to suit different clinical situation in the context of availability of resources, training, and according to economic feasibility. Thus, the local situation in any institute would influence applicability and will therefore have a significant impact on implementing a certain guideline. Nonetheless, this does not negate the importance of having guidelines based on best evidence [12]. Rather, it emphasizes the extent to which evidence obtained in a specific setting is generally valid or applicable to other situations.

Thus implementation of evidence-based guidelines is a challenge in many healthcare settings, and it is not often easy to evaluate application and consistency of performance in clinical practice. It has been stated that it takes approximately 5 years for any given guidelines to be accepted and adopted into routine clinical practice and often not fully followed [12, 13]. This is because of the multifactorial nature of implementing these guidelines, where implementation is influenced by the patient, healthcare providers, institutional facilities, and management; yet implementation is meant to overcome these obstacles [13, 14].

That is why guidelines take relatively a long time to implement using different tools to bypass these problems, for example, not only vigorous and continuous education aiming to train individuals but also to change beliefs and misconceptions reflected on certain behaviors that have become second nature, especially if the recommendation requires infrastructure or a device that is not available or the practice opposes the cultural norms of a specific setting/group. Implementation tools that increase guideline acceptability and accessibility must use a variety of user-friendly formats directed to deliver the knowledge to all those involved in the issue including patients and different groups of HCWs among different settings [14]. Also as most of the suggested guidelines are not subjected to rigorous economic evaluation, it is important to keep this point in focus alongside with effectiveness during implementation, by using surveillance feedback which provide guidance to staff and decision-makers to lever support for the appropriate allocation of resources and efforts, helping clinicians in selecting the best available evidence-based options in healthcare organizations with limited resources.

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