Overview of Surgical Site Infections (SSI)

Surgical site infections (SSIs) are a major source of postoperative illness and, less frequently, the cause of death among surgical patients in the U.S. Each year, approximately 500,000 surgical patients develop an SSI, complicating 2% to 5% of the estimated 27 million surgeries performed annually.\(^1\) Depending on the type of operation, e.g., colorectal surgery, the rate of SSI can be even higher, at close to 10%.\(^2\)

The Department of Health and Human Services has identified SSI as one of the four main categories of healthcare-associated infections (HAI) that occur in the acute care (hospital) setting.\(^3\) In fact, SSIs are the second-most common HAI, and account for 20% of the infections occurring among all hospitalized patients.\(^4\)

To track surgical site infection rates, hospitals may elect to submit information to the National Healthcare Safety Network (NHSN), a web-based surveillance system run by Centers for Disease Control and Prevention (CDC) for capturing data about adverse events, including HAI.\(^5\) It is important to keep in mind that the reported data may not accurately reflect the magnitude of the problem, as shortened hospital stays and the switch to performing surgery on an outpatient basis have impaired postoperative surveillance.\(^6\) An estimated 47% to 84% of SSIs occur after discharge\(^7\) and, therefore, go undetected by hospital infection surveillance programs.

SSIs increase the hospital length of stay by an average of 7.5 days. A CDC report using data from 2002 estimated that annual U.S. hospital costs associated with SSIs are in excess of $7 billion.\(^8\) In addition, there are substantial and incalculable indirect costs to patients, their families, their employers, the community, and society.

Despite the high incidence of SSIs, they are often preventable. Some prevention strategies are simple, such as hand washing, while others are more challenging, such as proper administration of antibiotics or maintaining tight control of blood glucose levels.

Although most hospitals and health systems have established appropriate protocols, many lack methods for measuring and reporting on compliance with such protocols.\(^9\) Studies have identified staff education, reporting of individualized performance data, and use of standard orders as strategies to improve compliance with SSI prevention guidelines and reduce SSI rates.\(^10\)
Overview of Surgical Site Infections (continued)

It is also clear that the public should be educated about the risks of SSIs and methods that can be used to prevent them. Informed and involved patients contribute to a safe hospital experience across many risk concerns. The single most important way to prevent infection while in the hospital and after discharge is hand washing. An environment where patients feel comfortable reminding caregivers to wash their hands is more likely to be safer.

The key to reducing SSIs is teamwork. Safety requires the active participation of all players in the local health care delivery system, including informed patients; concerned, alert teams of health care professionals; and enlightened policymakers, who, working in concert, will exponentially improve the chances of a safe surgical experience. Partnerships between the stakeholder representatives at every level of the health care experience (federal, state, and local governments; regulatory agencies; professional societies; hospitals and health systems; health insurers; employers and other purchasers; and consumer groups) are necessary to create an environment where safety is a key priority.

Definition of a surgical site infection

The NHSN has established nationally standardized surveillance criteria for defining and reporting on SSIs. Using standardized definitions across the industry allows for the comparison of rates by surgeon and by hospital. According to these criteria, SSIs are classified into the following three categories: superficial incisional surgical site infection, deep incisional surgical site infection, and organ-space surgical site infection.¹¹

**Superficial incisional surgical site infection** is defined as an infection occurring at the incision site within 30 days of surgery, involving only the skin and/or subcutaneous tissue at the incision, and exhibiting at least one of the following:

- Purulent drainage from the superficial incision;
- Organisms isolated by culturing fluid or tissue from the superficial incision;
- Deliberate opening of the wound by the surgeon because of the presence of at least one sign or symptom of infection (pain, tenderness, localized swelling, redness, or heat), unless the wound culture is negative; or
- Diagnosis of superficial incisional surgical site infection by the surgeon or attending physician.
Overview of Surgical Site Infections (continued)

**Deep incisional surgical site infection** is defined as an infection occurring at the incision site within 30 days of surgery if no implant was left in place, or within one year of surgery if an implant was left in place; when it appears to be related to surgery and involves deep soft tissue; and at least one of the following:

- Purulent drainage from a deep incision, but not from the organ-space component of the surgical site;
- Wound dehiscence or deliberate opening by the surgeon when the patient has a fever or localized pain or tenderness, unless the wound culture is negative;
- An abscess or other evidence of infection involving the deep incision seen on direct examination during re-operation, by histopathological examination, or by radiological examination; or
- Diagnosis of deep incisional surgical site infection by the surgeon or attending physician.

**Organ-space surgical site infection** is defined as an infection occurring within 30 days of surgery, if no implant was left in place, or within one year of surgery, if an implant was left in place; when it appears to be related to surgery; when it involves any part of the anatomy other than the incision that was opened or manipulated during an operation; and at least one of the following:

- Purulent drainage from a drain placed through a stab wound into the organ space;
- An organism isolated from an aseptically obtained culture of fluid or tissue in the organ or space;
- An abscess or other evidence of infection involving the organ or space seen on direct examination during surgery, by histopathological examination, or by radiological examination; or
- Diagnosis of an organ-space surgical site infection by the surgeon or attending physician.
Overview of Surgical Site Infections (continued)

**Microbiology**

The microbiology of SSIs is directly related to the type of surgery being performed and the natural bacterial flora of the organs involved in the procedure. Most SSIs are caused by gram-positive cocci, including *Staphylococcus aureus* (*S. aureus*) and *Staphylococcus epidermis*, organisms colonizing a patient's skin. Meanwhile, there is an increased likelihood of infection caused by gram-negative bacilli after surgery on the GI tract; *Enterococcus faecalis* and *Escherichia coli* are common pathogens after clean-contaminated surgery.\(^{12,13}\)

Table 1 expands upon various types of operations and the pathogens likely to cause a surgical site infection.\(^{14}\)

---

**TABLE 1. Common Pathogens by Surgical Procedure**

<table>
<thead>
<tr>
<th>Operations</th>
<th>Likely Pathogens*†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Placement of grafts, prostheses, implants</td>
<td><em>Staphylococcus aureus</em>; coagulase-negative or staphylococci</td>
</tr>
<tr>
<td>Cardiac</td>
<td><em>Staphylococcus aureus</em>; coagulase-negative staphylococci</td>
</tr>
<tr>
<td>Neurosurgery</td>
<td><em>Staphylococcus aureus</em>; coagulase-negative staphylococci</td>
</tr>
<tr>
<td>Breast</td>
<td><em>Staphylococcus aureus</em>; coagulase-negative staphylococci</td>
</tr>
<tr>
<td><strong>Ophthalmic</strong>. Limited data, however; commonly used in procedures such as anterior segment resection, vitrectomy, and scleral buckles</td>
<td><em>Staphylococcus aureus</em>; coagulase-negative staphylococci, streptococci, gram-negative bacilli</td>
</tr>
<tr>
<td><strong>Orthopedic</strong>. Total joint replacement, closed fractures/use of nails, bone plates, other internal fixation devices. Functional repair without implant/device. Trauma.</td>
<td><em>Staphylococcus aureus</em>; coagulase-negative staphylococci; gram-negative bacilli</td>
</tr>
<tr>
<td>Vascular</td>
<td><em>Staphylococcus aureus</em>; coagulase-negative staphylococci</td>
</tr>
<tr>
<td>Appendectomy</td>
<td>Gram-negative bacilli, anaerobes</td>
</tr>
<tr>
<td>Biliary tract</td>
<td>Gram-negative bacilli, anaerobes</td>
</tr>
<tr>
<td>Colorectal</td>
<td>Gram-negative bacilli, anaerobes</td>
</tr>
<tr>
<td>Gastroduodenal</td>
<td>Gram-negative bacilli; streptococci, oropharyngeal anaerobes (e.g. peptostreptococci)</td>
</tr>
<tr>
<td><strong>Head and neck.</strong> (Major procedures with incision through oropharyngeal mucosa.)</td>
<td><em>Staphylococcus aureus</em>; streptococci; oropharyngeal anaerobes (e.g. peptostreptococci)</td>
</tr>
<tr>
<td>Obstetrics and gynecologic</td>
<td>Gram-negative bacilli; enterococci; group B streptococci; anaerobes</td>
</tr>
<tr>
<td>Urologic (May not be beneficial if urine is sterile.)</td>
<td>Gram-negative bacilli</td>
</tr>
</tbody>
</table>

* Likely pathogens from both endogeneous and exogeneous sources.
† Staphylococci will be associated with surgical site infection following all types of operations.
Overview of Surgical Site Infections (continued)

Risk Factors

SSIs are the result of the disrupted balance between pathogenic organisms and the patient’s defense mechanism. According to the CDC, the risk of SSI can be expressed as the relationship between the infectious organism and the host resistance:

\[
\text{Risk of SSI} = \frac{\text{Contamination} \times \text{Virulence}}{\text{Host Resistance}}
\]

A multitude of factors, such as the patient’s health status, the physical environment in the operating room, and clinical interventions can contribute to the likelihood of developing an SSI. Although most SSIs can be attributed to the patient’s health status and individual risk factors, it is crucial to recognize the role that the surgeon and the operative team play by failing to adhere to evidence-based guidelines and recommendations.
Overview of Surgical Site Infections (continued)

**Wound Classification**

The CDC\(^4\) has established four wound classes based on the degree of contamination with pathogens. The evidence reveals that the risk of SSI increases if the surgical wound is contaminated with more than 105 microorganisms per gram of tissue. However, this threshold is reduced when foreign bodies, such as detritus, sutures, and drains, are present in the surgical wound.\(^{16}\)

**Clean (Class I)**

An uninfected operative wound, made in a location without inflammation and without entry into the respiratory, alimentary, genital, or uninfected urinary tract, is rated clean or Class I. Generally, clean wounds are closed primarily and, when drainage is necessary, a closed system is used. Even operative wounds that meet the above criteria, and are made in an area that has suffered blunt (e.g., non-penetrating) trauma, are still considered clean.

**Clean-contaminated (Class II)**

An operative wound in which the respiratory, alimentary, genital, or uninfected urinary tract is entered under controlled conditions, including controlled contamination by the contents of the relevant tract(s), is rated clean-contaminated or Class II. Specifically, operations involving the biliary tract, appendix, vagina, and oropharynx are included in this category, provided there is neither evidence of infection nor major break in technique.

**Contaminated (Class III)**

Contaminated or Class III wounds include those involving major breaks in sterile technique; major spillage from the gastrointestinal tract; and incisions in which acute, non-purulent inflammation is encountered. Additionally, traumatic wounds, if fresh and otherwise clean, are categorized as contaminated.

**Dirty-infected (Class IV)**

Old traumatic wounds with retained devitalized tissue or debris and those that involve active suppurative infection or perforated viscera are rated dirty-infected or Class IV. This definition suggests that the organisms causing postoperative infection were present in the wound before the operation.

It is important to note that this CDC wound classification method does not consider other risk factors for the development of wound infections. However, as discussed in the section on “Surveillance” below, the NHSN score comprises several separate measures covering various risk factors, including the CDC wound classification, the American Society of Anesthesiologists (ASA) Physical Status Classification System score, and the duration of surgery.
Overview of Surgical Site Infections (continued)

Patient-related risk factors
Certain patient characteristics and risk factors may interfere with the host-defense mechanism and may be a predictor for the development of SSI. These risk factors include, among others, advanced age, diabetes mellitus, poor nutritional status, remote infection, prior site irradiation, obesity, malignancy, alcoholism, smoking, corticosteroid treatment, and \textit{S. aureus} colonization of the nares. Evidence supporting some of these risk factors is described in detail below.

Diabetes mellitus
The pathophysiologic effects of diabetes impact the immune system and impair wound healing. Studies indicate that wound healing in diabetics is characterized by reduced collagen synthesis and deposition, decreased wound-breaking strength, and impaired leukocyte function. Patients with diabetes also experience impaired leukocyte chemotaxis, impaired phagocytosis, a decrease in the number of macrophages in the wound matrix, and impaired perfusion and tissue oxygenation as a result of the microvascular changes associated with diabetes. Many of the adverse effects of diabetes may be related to the patient’s level of glycemic control.\textsuperscript{17} Poor glycemic control in the immediate postoperative period, as measured by increased glucose levels (> 200 mg/dL), has been associated with an increased risk of SSI. Therefore, the CDC recommends adequate control of blood glucose in the perioperative period.\textsuperscript{18}

Obesity
Obesity is considered a strong independent risk factor for SSI and it is desirable for obese patients to lose as much weight as possible preoperatively.\textsuperscript{12} Poor wound perfusion and the available volume of relatively poorly vascularized and easily injured adipose tissue in obese patients contribute to the impairment in wound healing.\textsuperscript{19} The increased risk of SSI is thought to be due to diminished blood flow, increased wound area, and the added technical difficulty of handling adipose tissue.\textsuperscript{18} In addition to lower perfusion of the subcutaneous tissue, obesity is associated with longer operations and larger dead space in wounds that are primarily closed. Strategies to minimize SSI in the obese patient include tight glucose control, a larger dose of prophylactic antibiotics, and a laparoscopic approach, if possible, to diminish the size of the wound and eliminate the exposure of large areas of adipose tissue to injury and desiccation.\textsuperscript{20}
Overview of Surgical Site Infections (continued)

Smoking
Nicotine use delays primary wound healing and has been identified as an independent risk factor for SSI.\textsuperscript{16-18} Cigarette smoking is especially harmful to wound repair because it affects perfusion and oxygenation of the wound. Nicotine causes vasoconstriction and increased coagulability.\textsuperscript{17} Smokers should receive smoking cessation counseling, and the CDC recommends that the patient be instructed to abstain from tobacco products at least 30 days before the surgery.\textsuperscript{18}

Steroid treatment
Steroid treatment causes reduced inflammatory reaction, and may increase the risk of SSI. However, the evidence on the relationship between steroid use and SSI is contradictory.\textsuperscript{16,18} The CDC considers steroid use and SSI an unresolved issue, and currently there are no recommendations to taper or discontinue steroid use prior to surgery.\textsuperscript{18}

Nutritional status
Good nutritional status is critical to postoperative wound healing. Nutritional status strongly affects wound healing since the synthesis of protein is necessary for new tissue growth, for the regulation of the osmotic pressure of blood and other body fluids, and in the formation of prothrombin, enzymes, hormones, and antibodies. Adequate nutrition is critically important to maintain a competent immune system and to prevent infection in general. However, evidence of the benefits of preoperative nutritional repletion of malnourished patients in reducing SSI is inconclusive and the CDC currently does not offer a recommendation to enhance nutritional support solely as a means to prevent SSI.\textsuperscript{18}

Malnutrition contributes to increased morbidity and mortality. Malnutrition predisposes the patient to increased postoperative complications and potentially to impaired or failed wound healing. Additionally, patients with a history of previous surgery, trauma, radiation, or known compromised vascular circulation may experience delayed wound healing. Therefore, for these patients in particular, if time permits, optimization of nutritional status is wise, and nutritional assessment and planning should begin at the preoperative consultation. In reality, however, time often does not permit for nutritional optimization and, therefore, it behooves the surgical team to mitigate all other risk factors.
Overview of Surgical Site Infections (continued)

References


