CHAPTER 7

SURGICAL SITE INFECTIONS (SSI)

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INTRODUCTION

Surgical site infections (SSIs) are infections occurring within 30 days of a surgical procedure or within one year if an implant or prosthesis is inserted. They remain a common complication of surgical procedures despite advances in infection control measures. SSIs are an important cause of morbidity and mortality. SSIs occur due to several reasons including microbe-related, patient-related and procedure-related causes. SSIs bring a substantial financial burden on healthcare systems. SSIs are an important cause of readmission and prolonged length of stay in hospital. These infections can be classed as superficial, deep and organ/space infections. The most commonly isolated causative agent is *S. Aureus*. The diagnosis of SSIs is established with imaging investigations and cultures. Perioperative preventive measures are of paramount importance in SSIs. This chapter begins with epidemiology of SSIs and continues with their impact on healthcare systems, pathogenesis and risk factors. In addition, clinical features, pathogenesis, diagnosis and prevention of SSIs are discussed.

EPIDEMIOLOGY

Surgical site infection (SSI) is the most commonly seen health-care related infection following surgical procedures. SSI is associated with significant morbidity and mortality, prolongation of hospitalization, increased healthcare costs and hospital readmissions.

Over the past few centuries, the risk of surgery was exceedingly high due to higher rates of SSIs. Combined with the lack of effective anesthesia, the success rate was low. Aseptic approach has provided enormous gains to the surgery and only introduction of hand washing into daily practice has decreased mortality from puerperal sepsis from 12% to 2% (1).

Heterogeneity of surgical procedures and SSIs make epidemiological studies complicated with the incidence of SSIs differing significantly among procedures,

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healthcare centers, surgeons and patients (2). The incidence of SSIs among surgical patients has been reported as 2-4%, representing a considerable financial burden on the healthcare system (3). SSIs are associated with 38% mortality in patients with SSIs (4). Epidemiological studies from Europe have also reported as high as 20% incidence of SSIs depending on the procedure type and the criteria used (5).

The incidence of SSI's has dramatically decreased with the introduction of minimally invasive techniques. For example, the rate of SSI was reported as 1.1% in patients undergoing laparoscopic cholecystectomy, while this rate was 4% following open surgery (6). Similarly, The rate of SSIs with minimal invasive is lower due to smaller incision, decreased use of catheters, reduced postop pain, earlier mobilization and better protected immune function (5). Similarly, the rate of SSIs was reported as 2% with minimally invasive procedures and 8% with open procedures in patients undergoing appendectomy (5).

Today, more than 70% of surgical procedures are performed on an outpatient basis without hospitalization, making surveillance of SSIs difficult. Therefore, the incidence of SSI is thus dependent on voluntary self-reporting by surgeons.

IMPACT OF SSIS ON HEALTHCARE SYSTEMS

SSIs lead to a significant clinical burden. Patients with SSIs are more likely to present again to hospital or intensive care unit (ICU) due to SSIs. In addition, these patients are at a higher risk of mortality compared to those without SSIs. In 2020, Monahan et al. conducted a systematic review on the burden of SSIs on costs in 15 low – and middle-income countries and 16 European countries and found that the additional cost resulted from SSIs was similar between low – and middle-income countries ($174—$29,610) and European countries ($21—$34,000) (4).

SSIs are the most common form of hospital acquired infections. Approximately 160,000 to 300,000 SSIs are seen annually, accounting for more than 20% of hospital acquired infections (7). Whereas negative consequences of SSIs such as morbidity and mortality are well-known, there is only a little consensus on the financial system of the hospital (8). The estimated average cost of a SSI begings from 25,000 USD and raises up to 90,000 USD in the case of prosthetic implants (3). In the USA, total annual cost of SSIs is reported between 3.5 to 10 billion USD (7).

European data suggests that the mean cost of prolonged hospitalization due to SSIs is approximately €325 per day (2). When Figure 1 is examined; deep SSIs involving organs or body spaces are associated with higher rates of morbidity, longer length of stay in hospital, higher rates of readmission and costscompared to SSI's affecting only the incision.

PATHOGENESIS

Contamination should occur in the operation site for a SSI to occur. Risk of a SSI is calculated based on the following formula:

Risk of SSI = Dose of bacterial contaminant x virulence / Resistance of the host

As seen in the equation, the size of the inoculum is important. However, in the presence of any forign material, the number of organisms causing SSI is significantly lower. In endogenous infections, microorganisms that cause infections mainly originate from patients' skin or open viscus (9).

Exogenous infections develop due to microorganisms from surgical equipment, environment of the operating room, contaminated wounds, microorganisms that have accessed the wounds in the postoperative period and traumatic injuries (9). The resistance of a host is another aspect. The lower the ability of the body to overcome infection, the higher risk of getting SSIs. Trauma patients represent another high-risk population. The incidence of SSI following major intra-abdominal trauma surgery has been reported as 37% with up to 12% organ/space infections (10).

Complications Associated with SSIs

- Longer hospitalization that may lead to acquiring other hospital derived infections
- Further surgical interventions
- Risk of developing resistance to antibiotics
- Skin loss with necrotizing fasciitis
- Risk of amputation
- Cosmetically problematic scars
- Movement restrictions

RISK FACTORS

Several risk factors have been defined for SSIs and divided into two groups as patient related risk factors and procedure related risk factors. Patients who are undergoing longer or more complex surgeries or those who have a greater hospitalization and less fit patients are at a higher risk of developing SSIs. In addition, being colonized especially with S. Aureus or other pathogens, older age, and pre-existing infections are among the patient related risk factors (11). In general, patient related risk factors for developing SSIs include:

- Age
- Diabetes
- Obesity
- Smoking
- Nutritional status
- Immune response alterations
- Length of preoperative stay
- Preoperatively existing infections
- Being colonized especially with S.Aureus

Other numerous risk factors that are discussed below influence the incidence of SSIs. Despite asepsis and decontamination rules were followed, bacteria can enter the wound site from the operating room environment, equipment used, surgical personnel or patients' skin (12). Significant bacteria are present in the patients' bowels and stomachs. Patients over 70 years old and those with obstructive jaundice, acute cholecystitis or biliary duct stones have substantial concentration of bacteria in the biliary tract (13). However, SSIs are mostly the consequences of intraoperative contamination.

Tobacco Use: Cigarette smoking has been demonstrated to interact with malnutrition and associated with wound healing and decreased circulation to the skin due to increased nonfunctioning hemoglobin and platelet aggregation. Smoking has been found to suppress respiratory and immune systems. At least one month before surgery patients should be encouraged to stop smoking (14).

There are also several procedure related risk factors of SSIs including:

- Skin antisepsis
- Preoperative preparation
- Shaving
- Prophylaxis
- OR ventilation
- Surgical drains
- Surgical technique
- Duration of operation

In addition, there are other procedure related risk factors such as surgical site hematoma, necrotic tissue due to excessive use of electrocautery, suture materials in the surgical sites and dead space management.

The risk of developing SSI can be estimated for an individual using various indexes such as NNIS SSI Risk Index (2). This index consists of three items of which scored between 0-3:

1. The presence of contaminated, dirty or infected wounds.
2. An ASA (the American Society of Anesthesiologists) score >2
3. Duration of the procedure longer than nearly 75th percentile of the time of specific procedure being performed.

Microbiology

According to the American College of Surgeons, wounds are divided into four groups (15):

1. **Clean:** a surgery wound in which no inflammation and no infection is present. Alimentary, genital, respiratory or uninfected urinary tracts are closed.
2. **Clean-contaminated:** operative wounds that involve alimentary, genital, respiratory or urinary tracts, under controlled conditions, but do not involve unusual contamination. This class includes procedures performed on appendix, oropharynx, biliary tract and vagina.
3. **Contaminated:** this class of wounds includes fresh, open, accidental wounds, operation with major breaks using sterile methods and incisions in acute inflamed tissues including necrotic tissues as dry gangrene
4. **Dirty or infected:** wounds with visceral perforation or existing clinical infection. It has been in this group that the causative agents were present in the operation site before the procedure.

In most SSIs, the responsible microorganisms originate from endogenous flora of the patients. Although the pathogen isolated differs depending on the type of the procedure, the most commonly isolated pathogens include *S. aureus*, coagulase-negative staphylococci, Enterococcus spp. and *Escherichia coli* (16). In the USA gram-positive cocci are the most commonly encountered bacteria in SSIs (17). Among these pathogens, Methicillin-resistant Staphylococcus aureus (MRSA) is found abundantly, accounting for more than 40% of isolates (18). Gram negative bacteria (GNB) are increasingly becoming more important as causative agents in SSIs. More importantly, nearly half of GNBs isolated from surgical wards are multidrug resistant (19). Numerous SSIs are increasingly attributed to antibiotic-resistant GNBs, especially *S.aureus* (MRSA) and *Candida albicans*. This has resulted in an increased number of severely ill or immunocompromised surgical patients and widespread use of broad-spectrum-antibiotics (2). On the other hand, pathogens may originate from remote sites especially in case of prosthesis or other implants (20).

In addition to the endogenous flora of the patients, SSIs can also be caused by exogenous sources such as the environment of the operating room, surgical staff, surgical equipment and materials brought to the operating room under sterile conditions (21).

Clinical Features

The National Healthcare Safety Network (NHSN), of the Center for Disease Control and Prevention (CDC) classified SSIs into three classes as shown in Figure 1 (15).

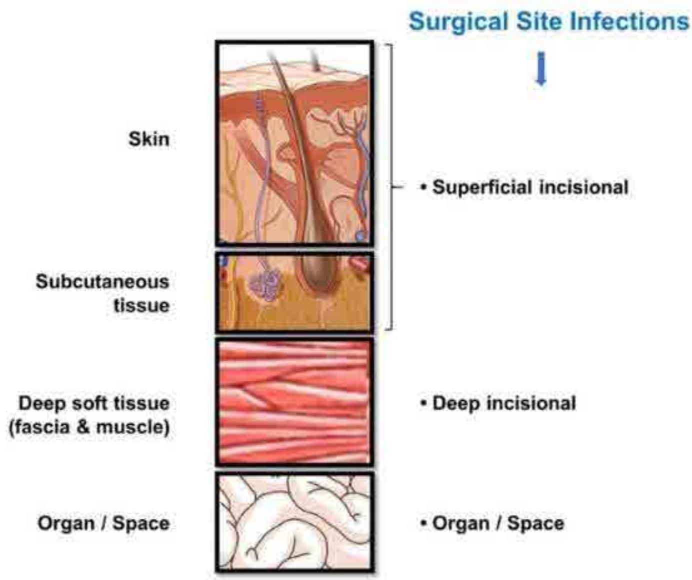

Figure 1. Classification of SSIs (Adapted from CDC).

In the case of clinical suspicion, the wound should be directly examined in order to facilitate visual inspection and surveillance. The patient may be evaluated while still hospitalized or after discharge as return visit depending on the severity of symptoms and the risk of potential complications due to the procedure performed.

Superficial Incisional Infection: Presence and extent of erythema and edema surrounding the wound is documented. Symptoms include wound breakdown and separation, wound dehiscence, drainage, warmth, localized swelling and pain in the infection site. Separation of the wound edges or purulent drainage usually indicate infection, eliminating the need for further surveillance, opening of the wound or imaging. However, sometimes wound dehiscence may occur without infection. The presence of surrounding erythema or purulence will distinguish an infected from uninfected dehiscence (22).

Deep incisional surgical site infection: An infection involving the fascia and/or muscle is indicative of deep incisional SSI. Symptoms are similar to those seen in superficial SSIs. Palpation of the wound shows tenderness. Deep incisional SSIs are more likely to be accompanied by local tenderness and fever. Signs of infection include leukocytosis, fever, and elevation of biomarkers of acute inflammation including C-reactive protein. Deep SSIs are difficult to diagnose clinically. Imaging may be helpful in estimating the depth and extent of infection. Deep SSIs are usually evaluated in the operating room. It is important to open the wound enough to explore underlying tissue (23).

Organ/space surgical site infection: Patients with organ/space SSI often present with fever, pain/tenderness in the relevant area, malaise and without overlying skin changes. This type of SSI can also be a result of the progression of a deep incisional SSI. Imaging examinations are performed to reveal an abscess in the organs or cavity involved in the procedure and Gram stain and culture analysis are performed to confirm the infection (24).

DIAGNOSIS

Diagnosis of SSIs is set with imaging studies and confirmed with cultures.

Imaging: Ultrasound is a widely available and effective method of identification of subcutaneous fluid. However, it does not work in the case of deep o organ/space SSIs. CT and MRI are helpful in these conditions and provide more detailed information of the soft tissue and organ space. Air and/or extraluminal contrast on imaging raises concerns about underlying perforation that should be intervened surgically (25).

Cultures: If there is an open wound in this initial evaluation or if the wound has been opened for exploration in the case of suspected SSI, causative organisms should be confirmed with Gram staining and culture studies. In the case of open wounds, swab cultures are obtained directly from the site of infection. Examination of surrounding skin complicated culture studies and makes differential diagnosis difficult. A sample of synthetic material such as surgical mesh and implant or necrotic material should also be sent for culture during surgical debridement. Results of Gram staining prompts initiation of the empiric therapy. However, specific therapy will be dependent on subsequent culture results. In an evidently negative culture condition, an infected wound can be a sign of underlying atypical infection or fungal infection. In the case of systemic signs of infection, concomitant blood cultures should also be obtained (2).

Differential Diagnosis of SSIs include:

- Skin erythema
- Stitch abscess
- Hematoma
- Seroma

PREVENTION

Prevention of SSIs is achieved by both reducing the risk of bacterial contamination and improving defense of the patients. However, the heterogeneous nature of SSIs make prevention of them challenging. Because of patient-related factors, findings of a specific study can not be easily generalized to a wider setting. However, there are always general measures to take in the pre – peri – and postoperative periods.

Preoperative Setting

Pre-existing infections at the area remote from the surgical sites should be treated. Obese patients should be encouraged to loww weight and smokers to giving up before the surgery.Before the operation, the skin should be cleaned with an antiseptic solution. If not necessary, hair shaving should be avoided because of the possibility of microscopic skin cuts that can be a potential site for subsequent infections. Antimicrobial prophylaxis should be used, if deemed appropriate (26).

Perioperative Setting

A good surgical technique and aseptic precautions are the mainstay of the preoperative measures. Good surgical technique requires attention to maintaining homeostasis, eliminating dead space in the surgical site and removal of foreign bodies. In order to prevent transmission of pathogens, sterile gloves, gowns, caps and facemasks should be used. Surgical equipment should be sterilized adequately (26).

Postoperative Setting

The risk of SSIs can persist for up to 30 days of the operation, but it may also be seen within one year in the case of an implant inserted. Of all SSIs, 12-84% are seen after the patient is discharged from the hospital. According to the CDC guidelines, incisions that have been closed for primary purposes should be protected for 24-48 hours and should be dressed using sterile technique (15).

CONCLUSION

Despite all advances and development of preventive measures, SSIs remain a serious public health problem associated with high rates of morbidity and mortality. SSIs implicate substantial economic burden on the healthcare system with readmission and prolonged hospitalization. Therefore, they continue to pose an important clinical challenge. It is important that much burden of morbidity and mortality from SSIs is preventable. It is evident that attention to patient and procedure-related risk factors and taking necessary measures timely leads to a decrease in the incidence of SSIs.

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