Chapter 15

# Prevention of Surgical Site Infections

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| Key Points |
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| • Surgical site infections are one of the most common healthcare-associated infections.<br>• Evidence-based measures exist that are effective in reducing surgical site infections.<br>• Although sterilisation of instruments, aseptic technique, clean air, and antimicrobial prophylaxis have been shown to reduce the incidence of surgical site infections, it remains an important cause of morbidity and mortality worldwide.<br>• Risk factors involve the patient, the operation itself, and the environment. |

## Introduction

Surgical site infections (SSI) are one of the most important healthcare-associated infections (HAI). In many countries, SSIs account for up to 31% of HAIs. It is estimated that up to 60% of SSIs are preventable by using evidence-based guidelines. SSIs may prolong hospital stay from 6-30 days, increase antimicrobial and laboratory costs, and require additional health care interventions.[1]

Despite an understanding of infection prevention and control (IPC) measures and, although sterilisation of instruments, aseptic technique, clean air, and antimicrobial prophylaxis have reduced the incidence of SSI, the rate remains unacceptably high. It is an important cause of morbidity and mortality. This is due to breaches in good IPC practices, host risk factors, and/or the complexity of the procedure. The development of a SSI is multi-factorial; in general, it is impossible to determine an exact cause.

## Risk Factors

Patient risk factors, types of surgical procedures, and the operating room environment have been associated with an increased risk of SSI. These risk factors are outlined in Tables 15.1 – 15.3.

**Table 15.1**. Patient risk factors for surgical site infection (SSI)

| Risk Factor | Comments |
|---|---|
| Nutritional status[2] | Some studies of malnutrition demonstrate that is a risk factor for SSI. The benefits of preoperative total parenteral nutrition in reducing the risk are not proven. |
| Diabetes[2-4] | There is a significant relationship between increased glucose levels (>200 mg/dl or 180 mg/dl in cardiac surgery) in the perioperative period and the risk of SSI. Good glycaemia control and stable serum glucose concentration is essential. |
| Smoking[5-6] | Nicotine delays wound healing; studies have associated cigarette smoking with an increase in SSI. Cessation of smoking 30 days before elective surgical procedures is recommended. |
| Obesity[4,7-8] | Obesity (Body Mass Index >40) has been associated with SSI, especially after cardiac and orthopaedic implant surgery. |
| Coexisting remote | Active infection, especially of the skin and respiratory tract, increases SSI risk in all types of surgery. |
| Colonisation with microorganisms[9] | Nasal carriage of *S. aureus* is a risk factor for SSI. In cardiac and orthopaedic surgery, studies support screening and decolonisation before surgery, especially when the hospital has high rates of SSI caused by this agent. |
| Length of preoperative stay[8,10] | Prolonged preoperative hospitalisation has been associated with increased SSI risk, probably because it may be an indicator of severe underlying illness. |
| Perioperative | SSI has been associated with perioperative transfusion. However, interpretation of data is difficult due to methodological problems. |

**Table 15.2.** Operative risk factors for surgical site infection (SSI)

| Risk Factor | Comments |
|---|---|
| Colonisation of the operative site - Antiseptic bath[3] | A preoperative antiseptic shower or bath decreases skin microbial colony counts; however it has not definitively been shown to reduce SSI rates. |
| Colonisation of the operative site - Skin antisepsis[4,11] | Antiseptics decrease skin colonisation of microorganisms. Preoperative skin preparation with an antiseptic solution is recommended for all operations; iodophores, alcohols, and chlorhexidine are most commonly used. Current data suggest that alcoholic solutions (in combination with chlorhexidine or iodophores) should be used unless contraindicated. More studies are needed to choose between chlorhexidine and iodophores. |
| Colonisation of the surgical team - Surgical scrub[,4-5] | The aim of a surgical scrub/rub is to reduce colonisation of the surgical team's hands. Various antiseptics have been used, e.g., alcohols, chlorhexidine, iodine/ iodophores, parachloro-meta-xylenol, and triclosan. Isopropyl alcohol is considered the gold standard due to its rapid effect; chlorhexidine is used for its persistent action. Artificial nails increase bacterial and fungal colonisation of the hands despite adequate hand scrubs. No clinical trials have evaluated the effectiveness of surgical scrubs on SSI. |
| Preoperative shaving[3,5] | Preoperative shaving of the surgical site is associated with a significantly higher SSI risk than using depilatory agents or no hair removal. Clipping hair immediately before an operation lessens the risk. However, the risk from either shaving or clipping increases when it is performed the night before surgery. Use of depilatories is better; however, it sometimes causes hypersensitivity. Some studies demonstrate that any hair removal is associated with increased SSI rates and suggest that no hair should be removed unless essential to the procedure. |
| Infected or colonised surgical personnel[12] | Personnel with skin diseases, such as psoriasis, active infections, or who are colonised with microorganisms, such as staphylococci, have been linked to outbreaks of SSIs. Health care organisations should exclude infected individuals from surgical activities. |
| Duration of operation[7] | Lengthy operations are associated with an increased risk of SSI. Operation time should be kept to a minimum. |
| Contamination of the operative site - Antimicrobial prophylaxis[3-4,10] | Antimicrobial prophylaxis reduces SSI and is recommended when a SSI would represent a catastrophe, e.g., in orthopaedic and other high-risk procedures. A single dose (according with the weight of the patient) is usually sufficient; timed to have a bactericidal concentration of the drug in the tissues at the time of the incision. Usually it is given at the induction of anaesthesia or, in any case, not more than 30 minutes before the skin is incised. The prophylactic agent should be safe, inexpensive, and have a spectrum that covers likely intraoperative contaminants. First and second generation cephalosporins are often used, e.g., cefazolin or cefuroxime. A second dose is recommended if the operation lasts >3 hours or involves rapid blood loss. |
| Foreign material in the surgical site (sutures and drains)[5] | A foreign body may promote inflammation and act as a point of entry for microorganisms. Drains used to evacuate postoperative haematomas or serous fluids in the post-operative period increase incisional SSI risk. Drains should be passed through a separate incision away from the operative wound and removed as soon as possible; use closed suction. Monofilament suture material is the least irritating. |
| Hypothermia[3-4] | Hypothermia causes vasoconstriction, decreased delivery of oxygen to the wound space, and impairment of leukocyte function. |
| Surgical technique[7] | Breaks in aseptic technique, such as use of communal syringes or contamination of intravenous fluids or equipment, have been associated with SSI. Good surgical technique (effective homeostasis, gentle handling of tissues, and removal of devitalised tissues) reduces the risk. The risk of SSI is strongly associated with the experience of surgical teams. Institutions should select experienced surgeons for complex interventions and monitor surgical technique. |

**Table 15.3**. Environmental risk factors for surgical site infection (SSI)

| Risk Factor | Comments |
|---|---|
| Operating room ventilation[13-14] | An operating room should be at positive pressure relative to adjacent areas and supplied with enough filtered air to provide at least 20 air changes per hour. Use of ultra-clean air in the prevention of SSI in implant surgery is well established. Use of ultraviolet radiation has not been shown to decrease SSI. The microbial count in operating room air is directly proportional to the number of people and their movement; movement must be controlled and numbers kept to a minimum. |
| Inanimate surfaces[5] | Environmental surfaces, i.e., floor, walls, or tables, have not been associated with SSIs. There are no data to support the use of environmental disinfectants. Tacky mats placed outside the theatre entrance and use of overshoes is unnecessary. |
| Inadequate sterilisation of instruments[14] | Sterilisation of instruments is an essential part of aseptic technique and must be performed using validated methods. Inadequate sterilisation has been associated with increased SSI rates and outbreaks.<br><br>Flash sterilisation should only be performed in an emergency. There are issues with absence of protective packaging, possibility for contamination of processed items during transportation, and difficulty in monitoring cycle parameters (time, temperature, and pressure). Flash sterilisation should be never be used for implants or invasive devices. Flash sterilisation may also be called immediate-use. |
| Contamination from the surgical team - Surgical clothes and gloves[4-5] | Barrier clothing and gloves are necessary to minimise exposure of a patient's wound to the skin, mucous membranes, and hair of the surgical team. It also protects the team from exposure to a patient's blood. Masks can prevent contamination of patients with respiratory pathogens. Surgical caps reduce contamination of the surgical field by microbes from the hair and scalp. Footwear should be enclosed and protect the team from accidentally dropped sharps and other contaminated items; open footwear must never be worn. If there is a risk of spillage of blood or other high-risk body fluids, surgical waterproof boots should be worn.<br><br>Sterile gloves minimise transmission of microbes from the hands of the surgical team to patients and prevent contamination of team members from patients' blood and body fluids. Wearing two pairs of gloves may provide added protection. |

## Surveillance[5, 15-18]

Surveillance for SSIs with appropriate feedback to surgeons has been shown to reduce SSI risk. Many SSIs are detected after the patient leaves hospital. Therefore, post-discharge surveillance is essential (particularly for day cases). However, this activity is resource intensive, requiring direct examination of patients, review of medical records, or patient surveys by mail/telephone.[19-20]

A surveillance system should include use of standard definitions and risk stratification. A frequent criterion used to identify a SSI is purulent drainage from the incision or from the site of a drain with either a positive or negative culture. An infection occurring within 30 days of an operation <u>or</u> within 1 year of an implant procedure is classified as a SSI. Definitions from the USA Centers for Disease Control and Prevention are often used.[5]

**Some countries recommend SSI surveillance based on a specific surgery (e.g., cholecystectomy, hernia repair, Caesarean section, hip replacement, knee replacement, hysterectomy, colon surgery, etc.). This approach assumes that patients having similar operations have similar risk factors. If this type of surveillance is performed, it is essential to choose surgeries based on the hospital's experience with SSIs (frequency, epidemiological importance, and data availability among other factors).**

The rates of SSIs must be calculated based on the specific risk of the patients. Risk stratification or standardisation is necessary because not all the operations or patients have the same risk of infection.[18] There are several methods to classify SSI in relation to risk. The first method is by type of surgery: clean, clean-contaminated, contaminated, or dirty. The main predictor of SSI for this method is regarded as the intrinsic degree of wound contamination.

Another approach is to compare the clean wound SSI rates of different surgeons. This strategy has been shown to decrease SSIs in some studies. However, it may be unpopular and unfair if the data are not adjusted for patients' risk factors.

The former NNIS (National Nosocomial Infection Surveillance – now the National Healthcare Safety Network) system in the USA developed a method that used the type of surgery classification, the duration of an operation, and the ASA (American Society of Anesthesiologists) score as its SSI risk stratification system. This method demonstrated that the degree of contamination is not the only predictor of SSI.

Standardised infection ratios (SIR) for SSI data may also be used. The SSI SIR is the result of logistic regression modelling that considers all procedure-level data in order to provide better risk adjustment than afforded by the NHSN risk index.[21]

The rates of SSI can be calculated considering all interventions or stratifying infections by superficial incisional (procedures involving only skin or subcutaneous tissue of the incision), deep incisional (involving fascia and/or muscular layers) or organ/space (involving any part of the body opened or manipulated during the procedure, excluding skin incision, fascia, or muscle layers). The decision depends on how the information will be used. Deep or organ space infections are more severe; however in terms of prevention separate rates don't provide additional data because the measures used to prevent SSI are the same.

Surveillance must start 24–48 hours postoperatively by review of microbiology reports and patient medical records. In cases in which the patient has a short hospital stay or an ambulatory surgery, surveillance must be performed after discharge. The proportion of SSIs detected through post-discharge surveillance can vary by surveillance method, operative setting, type of SSI, and procedure. To date, no standardised method for post-discharge surveillance has been established; however for patients that return to the same facility for post- operative care or for management of complications, the review of records by infection control professionals can provide higher sensitivity. Phone interviews have also been shown to provide good results.

In general superficial SSIs are most commonly detected and managed in the outpatient setting. Deep incisional and organ/space infections require readmission to the hospital and are typically detected at that time. Is important to take into account that up to 70% of SSI are detected after discharge.[19-20]

Benchmarking and comparing rates of SSI with other institutions requires care since there may be potential bias introduced by differences in surveillance systems and post- discharge surveillance methods. Automated data systems can be used to broaden SSI surveillance.

## Basic Recommendations for Prevention[3-5, 7-11, 13-14, 22]

### Preoperative

- Identify and treat all infections before elective operations.
- Maintain good control of diabetes.
- Keep preoperative hospital stay to a minimum.
- Do not remove hair preoperatively unless the hair at or around the incision site will interfere with the operation. If considered essential, remove hair immediately before the operation with a non-invasive procedure, e.g., clipper. Use of razors is considered inappropriate.
- Use an antiseptic for skin preparation. If no contraindication exists, use alcohol -containing preoperative skin preparatory agents combined with chlorhexidine gluconate or an iodophore. Alcohol is contraindicated for certain procedures; these include procedures in which the preparatory agent may pool or not dry creating a fire risk or procedures involving mucosa, cornea, or

ear.

- Perform a preoperative surgical scrub for 2-4 minutes using an appropriate antiseptic. A surgical scrub can be performed using water-less products (e.g., alcohol-based hand rubs) in the absence of visibly dirty hands. Do not use a brush. Remove debris underneath the fingernails using a nail cleaner before the first procedure in the morning.
- Exclude personnel who have signs and symptoms of a transmissible infection from surgical activities. Personnel with draining skin lesions must be excluded until the infection is fully resolved.
- Administer prophylactic antibiotics according to local policy. Increase dosing of prophylactic antimicrobial agent for morbidly obese patients or when the procedure lasts more than three hours. Stop agent within 24 hours after the procedure.
- Consider screening and decolonisation of carriers of *S. aureus* for high-risk procedures (e.g., orthopedic and cardiothoracic procedures) if the SSI rates for this microbe are high and not controlled by routine infection prevention measures.
- Determine the level of experience required for surgeons performing complex surgeries.
- Encourage smoking cessation in the 30 days prior to an elective surgery procedure.

**Intraoperative**

- Use a surgical checklist to ensure compliance with best practices. Use of a WHO checklist has been associated with less surgical complications including SSI.[22]
- Limit the duration of the procedure as much as possible.
- Sterilise all surgical instruments with validated methods. Do not use flash sterilisation routinely.
- Wear sterile gloves. Put gloves on after donning a sterile gown. Use water-repellent surgical gowns and drapes. Wear a surgical mask and a cap or hood to fully cover hair.
- Maintain positive pressure ventilation in the operating room with respect to the corridors and adjacent areas. Twenty air changes per hour are recommended. Filter all air; whether recirculated or fresh air.
- Keep operating room doors closed except as needed for passage of equipment, personnel, and the patient.
- Restrict entrance to the operating room to necessary personnel only and restrict their movement as much as possible.
- Adhere to principles of asepsis when performing interventions and invasive procedures in the operating room, e.g., when placing central venous, spinal, or epidural anaesthesia catheters or when dispensing and administering intravenous drugs.
- Handle tissue gently, maintain effective homeostasis, minimise devitalised tissue and foreign bodies (e.g., sutures, charred tissues, necrotic debris), and eliminate dead space at the surgical site.
- Use drains only if is necessary due to the patient's condition; then use closed suction drains. Place a drain through a separate incision distant from the operative incision. Remove it as soon as possible.
- Keep the body temperature of the patient between 36.5 and 37°C during the operation (normothermia) in surgical patients who have anaesthesia duration of

at least (over) 60 minutes.

- Keep the glycaemia level to <200 mg/dL during the operation (normoglycaemia).
- Avoid use of artificial nails among the surgical team.
- Do not perform special cleaning or closing of operating rooms after contaminated or dirty operations.
- Do not use over-shoes or tacky mats at the entrance to the operating room suite.
- Perform audits to identify adherence to IPC practices, e.g., antimicrobial prophylaxis, skin preparation, operative technique, level of operating room traffic, normothermia, and normoglycaemia.

**Post-operative**

- Don't touch the surgical wound unless it is necessary; if so, wear sterile gloves.
- Review daily the necessity of continuing use of drains and take out when no longer necessary.
- Have an on-going surveillance system for SSIs using standard definitions and risk classifications. Perform post-discharge surveillance for ambulatory surgery or short stay patients.

## Low Resource Issues

Surgical site infections are typically higher in developing nations than in high-resource countries.[23] Minimal requirements for the prevention of SSIs include:

- Do not remove hair preoperatively unless hair at or around the incision site will interfere with the operation.
- Perform glycaemia control in cardiac and vascular surgery.
- Use an antiseptic agent for skin preparation immediately prior to the operation.
- Perform a preoperative surgical scrub using an antiseptic product.
- Administer a prophylactic antimicrobial agent when indicated according to established criteria.
- Sterilise all surgical instruments with validated methods.
- Adhere to principles of asepsis when performing interventions or invasive procedures in the operating room.
- Have an on-going surveillance system for SSI using standard definitions and risk classifications.

## Summary

Research has shown that surgical technique, skin preparation, and the timing and method of wound closure influence the incidence of subsequent infection. Antibiotic prophylaxis has had a positive impact after certain types of surgery. Recently care bundles have been demonstrated to be a strategy that can be used to reduce the risk of SSI. Most bundles include core interventions, such as antibiotic administration, appropriate hair removal, glycaemic control, and normothermia. Individual studies of care bundles report conflicting outcomes; most of them conclude that use of an evidence-based, surgical care bundle in patients undergoing surgery significantly reduced the risk of SSI.[24-25]

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