# Chapter 11
# Prevention of Surgical Site Infections

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**Key points**

- In many countries surgical site infections are the most common healthcare-associated infections accounting for up to 25% of infections.
- Although sterilisation of instruments, aseptic technique, clean air and antimicrobial prophylaxis have been shown to reduce the incidence of SSI, it remains an important cause of morbidity and mortality worldwide.
- Risk factors involve the patient, the operation, and the environment.

## Introduction

Surgical site infections (SSI) are one of the most important healthcare-associated infections (HAI). In many countries SSI account for up to 25% of HAIs. SSIs may prolong hospital stay after surgery from 6-30 days, increase antimicrobial prescribing and laboratory costs, and require added interventions. Although sterilisation of instruments, aseptic technique, clean air and antimicrobial prophylaxis reduce the incidence of SSI, it remains an important cause of morbidity and mortality.

Microorganisms responsible for SSI can be either endogenous (from the patient) or exogenous (from the hands of personnel or the inanimate environment). Some are deep-seated and may occur many months after surgery.

By definition, any infection occurring within 30 days of an operation *or* within 1 year of an implant procedure is classified as a SSI. Infection rates vary with wound contamination.

More than 30% of SSIs are detected after the patient leaves hospital. Therefore post-discharge surveillance is essential (particularly for day cases). However this type of surveillance is resource intensive requiring direct examination of patients, review of medical records, or patient surveys by mail/telephone.

## Surveillance

Surveillance of SSIs with appropriate feedback to surgeons has been shown to reduce SSI risk. A surveillance system should include standard definitions and risk stratification of patients. The main predictor of SSI was regarded as the intrinsic degree of wound contamination. Wounds were classified as clean, clean contaminated, contaminated and dirty (1964 NAS/NRC Cooperative Research* ).

Many SSI surveillance systems also include the duration of an operation and ASA (American Society of Anesthesiologists) score to their SSI risk stratification system.

Some recommend SSI surveillance based on specific surgery (e.g., cholecystectomy, hernia repair, Caesarean section, hip replacement).

This approach assumes that patients having similar operations have similar risk factors. Another approach is to compare the clean wound SSI rates from 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 patient's risk factors.

## Risk Factors and Prevention Measures

Patient risk factors, surgical team practices, and the operating room have been associated with an increased risk of SSI. Recommendations for the prevention of SSI should be evidence based; however, evidence for lowering SSI rates in clean surgical procedures requires large, costly studies. Surrogate markers for infection are often used, e.g., wound cultures and length of stay.

### Patient Risk Factors

#### Nutritional Status

In theory malnutrition should increase the risk of SSI. However, this is difficult to demonstrate. Some studies of malnutrition predict mortality but not SSI. The benefits of preoperative total parenteral nutrition in reducing SSI risk are not proven and also has a risk of infection; however providing appropriate nourishment prior to an operation is important.

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***Class I/Clean:** An uninfected operative wound in which no inflammation is encountered and the respiratory, alimentary, genital, or uninfected urinary tract is not entered. In addition, clean wounds are primarily closed and, if necessary, drained with closed drainage. Operative incisional wounds that follow non-penetrating (blunt) trauma should be included in this category if they meet the criteria.

**Class II/Clean-Contaminated:** An operative wound in which the respiratory, alimentary, genital or urinary tracts are entered under controlled conditions and without unusual contamination. Specifically, operations involving the biliary tract, appendix, vagina, and oropharynx are included in this category, provided no evidence of infection or major break in technique is encountered.

**Class III/Contaminated:** Open, fresh, accidental wounds. In addition, operations with major breaks in sterile technique (e.g., open cardiac massage) or gross spillage from the gastrointestinal tract, and incisions in which acute, non purulent inflammation is encountered are included in this category.

**Class IV/Dirty-Infected:** Old traumatic wounds with retained devitalized tissue and those that involve existing clinical infection or perforated viscera. This definition suggests that the microorganisms causing postoperative infection were present in the operative field before the operation.

**Diabetes**
There is a significant relationship between increased glucose levels (>200 mg/dL) in the peri-operative period with risk of SSI. Good diabetes control is essential.

**Obesity**
Obesity (Body Mass Index >40) has been associated with SSI especially after cardiac and orthopaedic implant surgery.

**Coexistent Remote Infections**
Active infection, especially of the skin and respiratory tract, increase the risk of SSI in all types of surgery. Urinary tract and dental infections have been related to SSI following orthopaedic implants.

**Colonisation with Microorganisms**
Nasal and skin carriage of *S. aureus* is a risk factor for SSI. A preoperative antiseptic shower or bath decreases microbial colony counts on skin, however it has not been shown to definitively reduce SSI rates.

**Length of Preoperative Stay**
Prolonged preoperative hospitalisation has been associated with increased SSI risk, probably because it may indicate severe illness. In addition, patients may become colonised with resistant bacteria while in the hospital.

**Antimicrobial Prophylaxis**
Antimicrobial prophylaxis reduces SSI and is recommended when a SSI would represent a catastrophe, e.g., in orthopaedic and other high-risk (cardiac) implant procedures. A single dose is usually sufficient (maximum of 3), timed to give a bactericidal concentration of the drug in the tissues at the time of the incision. Usually it is given at the induction of anaesthesia, and 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 for prophylaxis, e.g., cefazolin 1-2 g or cefuroxime 1.5 g. A second dose is recommended in some studies if the operation lasts >3 hours or involves rapid blood loss.

Prophylaxis is not indicated in contaminated or dirty interventions, when treatment is required.

**Preoperative Shaving**

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, but sometimes causes hypersensitivity. In addition, depilatories are expensive and may cause skin damage; they are no longer recommended. Some studies show that any hair removal is associated with increased SSI rates and suggest that no hair should be removed unless essential.

**Skin Antisepsis**

Disinfection of the surgical site immediately prior to the incision reduces SSI rates. Antiseptics decrease skin colonisation of microorganisms. Preoperative skin preparation with an antiseptic solution is recommended for all operations. Alcohol, usually combined with chlorhexidine or iodophores, is strongly recommended.

## Surgical Team Risk Factors

**Surgical Scrub**

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 effective and rapid-acting; chlorhexidine is also used because of its persistent action. Artificial nails increase bacterial and fungal colonisation of the hands despite adequate hand scrubs. The use of a brush during a surgical scrub has not been associated with reduction of SSI.

**Infected or Colonized Surgical Personnel**

Personnel with skin diseases such as psoriasis or active infections or who are colonised with microorganisms such as staphylococci have been linked to outbreaks of SSIs. Healthcare organisations should exclude infected individuals from surgical activities whenever feasible.

**Duration of Operation**
Lengthy operations are associated with increased risk of SSI. Long exposures of tissues could be due to poor surgical technique, poor organisation in the operating room, or failure of common procedures such as provision of correct instruments, intra-operative radiology or microscopy. Operation time should be kept to a minimum.

**Foreign Material in the Surgical Site**
Foreign bodies, such as sutures and drains, 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.

**Aseptic and Surgical Technique**
Breaks in aseptic technique such as use of communal syringes or contamination of intravenous fluids or equipment have been associated with SSI. Hypothermia causes vasoconstriction, decreased delivery of oxygen to the wound space, and impairment of leukocyte function, and is also a risk factor.

The risk of SSI is strongly associated with the experience of surgical teams. Good surgical technique (effective homeostasis, gentle handling of tissues and removal of devitalized tissues) reduces the risk of SSI. Institutions should select experienced surgeons for complex interventions and monitor surgical technique.

## Operating Room Environment Risk Factors

**Ventilation**
The microbial count in operating room air is directly proportional to the number of people present and their movement. Therefore movement must be controlled and numbers kept to a minimum.

An operating room should be at positive pressure to adjacent areas and supplied with enough filtered air to provide 20 air changes per hour. This will help dilute contaminants in the air, e.g., microorganisms and gases. Use of ultra-clean air in the prevention of SSI in implant surgery is well established. Ultraviolet radiation has not been shown to decrease SSI.

**Sterilisation of Instruments**
Sterilisation of instruments is an essential part of aseptic technique and must be performed with validated methods using appropriate quality control. Flash sterilisation should only be used in an emergency, because of lack of indicators, 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.

**Surgical Clothes**
Barrier clothing is necessary to minimise exposure of a patient's wound to the skin, mucous membranes, and hair of the surgical team; clothing is also used to protect 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, blood, and other contaminated items. If there is a risk of spillage of blood or other high-risk body fluids, surgical waterproof boots should be worn. Plastic overshoes must not be used to protect footwear.

**Gloves**
Sterile gloves minimize transmission of microbes from the hands of the surgical team to patients and prevent contamination of team members with blood and body fluids. Gloves may also reduce the risk of infection through sharps injuries. Wearing two pairs of gloves provides added protection and may be used for orthopaedic procedures.

**Inanimate Surfaces**
Environmental surfaces (floor, walls, tables, etc.) have not been associated with SSI. There are no data to support the use of environmental disinfectants. Tacky mats placed outside the theatre entrance and use of overshoes are unnecessary.

## Prevention Recommendations

### The Patient

- Identify and treat all infections before elective operations.
- 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.
- Good control of diabetes is essential in the perioperative period.
- Use an antiseptic for skin preparation.
- Administer prophylactic antibiotics when indicated according to established criteria and local policy.

## The Surgical Team

- Perform a preoperative surgical scrub for at least 2-4 minutes using an appropriate antiseptic. Do not use a brush. Remove debris underneath the fingernails using a nail cleaner before the first procedure in the morning.
- Personnel with draining skin lesions must be excluded from surgical activities until it is fully resolved.
- Limit the duration of the procedure as much as possible.
- Wear sterile gloves. Put gloves on after donning a sterile gown. Use sterile water repellent surgical gowns and drapes. Wear a surgical mask and a cap or hood to fully cover hair.
- Adhere to principles of asepsis when performing interventions and invasive procedures in the operating room, e.g., placing central venous, spinal or epidural anaesthesia catheters or when dispensing and administering intravenous drugs.
- Handle tissue gently, maintain effective homeostasis, minimize devitalized tissue and foreign bodies (e.g., sutures, charred tissues, necrotic debris), and eradicate dead space at the surgical site.
- Use closed suction drains. Place a drain through a separate incision distant from the operative incision. Remove it as soon as possible.

## The Operating Room Environment

- 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, recirculated and fresh.
- Keep operating room doors closed except as needed for passage of equipment, personnel, and the patient.

- Restrict the number of personnel entering the operating room to necessary personnel only, and restrict their movement.
- Sterilise all surgical instruments with validated methods. Do not use flash sterilisation routinely.
- Do not perform special cleaning or closing of operating rooms after contaminated or dirty operations.
- Do not use over-shoes and tacky mats at the entrance to the operating room suite.

### Postoperative

- Don't touch the wound unless it is necessary.
- Have an on-going surveillance system for SSI using standard definitions and risk classifications. Perform post-discharge surveillance for patients with ambulatory surgery or a short hospital stay.

## References and Further Reading

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