A Review on Preventive Measures of Surgical Site Infections

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ABSTRACT

Surgical site infections (SSIs) are one of the most common source known to cause the nosocomial infection. These have economic impacts on the health care system, also results in increased length of hospital stay and in turn causes hospital costs rising. Most of the surgical site infections (SSIs) are preventable in nature. The common pathogens responsible for SSI are Staphylococcus aureus, Enterococcus spp. and Escherichia coli. Practices to prevent SSI are aimed at minimising the number of micro-organisms introduced into the operative site during the preoperative, intraoperative and postoperative duration by following the standard procedures and guidelines. Implementing multidisciplinary strategies in SSI prevention must be consistently applied as per the needs of the individual patient and health care organization. This review has identified that using a bundled approach, sharing responsibility, and adhering to best practice are strategies used by health care professional teams in the prevention of SSI.

KEY WORDS: Surgical site infection, Nosocomial infection, Escherichia coli, Enterococcus spp; Staphylococcus aureus.

1. INTRODUCTION:

Surgical site infections (SSIs) are one of the most common source known to cause the nosocomial infection.\(^1\)\(^,\)\(^2\) Despite of remarkable advancement done for the use of surgical techniques and prophylactic antibi-otics and environmental improvements in the operating room, surgical site infections (SSIs) remain a significant cause of patient morbidity and mortality.\(^3\)\(^-\)\(^5\) Most of the surgical site infections (SSIs) are preventable in nature but concern is that surgical site infections (SSIs) occur in up to 30% of the surgical procedures.\(^6\)\(^-\)\(^7\) These have economic impacts on the health care system, also results in increased length of hospital stay and in turn causes hospital costs rising from twofold to fivefold.\(^5\)\(^-\)\(^9\) An surgical site infection (SSI) is an infection related to an operative procedure that occurs at or near the surgical incision within thirty days to one year of the procedure.\(^10\)\(^,\)\(^11\) The Centers for Disease Control and Prevention (CDC) and the National Nosocomial Infection Surveillance System (NNIS) defines surgical site infections (SSIs) by the following clinical criteria:

1. A purulent exudate draining from a surgical site
2. A positive culture obtained from a surgical site that was closed initially
3. A surgeon’s diagnosis of infection
4. A surgical site that requires reopening due to at one of the following signs or symptoms: tenderness, swelling, redness, or heat \(^2\)\(^,\)\(^10\)\(^,\)\(^12\)

The Centers for Disease Control and Prevention (CDC) defines surgical site infections (SSIs) as “An infection that occurs after surgery in the part of the body where the surgery took place.”\(^13\)\(^,\)\(^44\) CDC revised the definition of “wound infection” in 1992, and created the definition: “surgical site Infection”, in order to prevent the confusion between the infection of a surgical incision and the infection related to any traumatic wound.\(^14\)\(^,\)\(^26\) Surgical site infections (SSIs) are defined as infections of skin or underlying soft tissues at the surgical site, occurring within 30 days following National Healthcare Safety Network (NHSN) operative procedure in which an incision was closed primarily. An NHSN operative procedure is a procedure that is performed on a patient who is an NHSN inpatient (A patient whose date of admission to the healthcare facility and the date of discharge are different calendar days) or an NHSN outpatient (A patient whose date of admission to the healthcare facility and date of discharge are the same calendar day); and takes place during an operation (defined as a single trip to the operating room where a surgeon makes at least one incision through the skin or mucous membrane, including laparoscopic approach, and closes the incision primarily before the patient leaves the operation room.\(^14\)
The Centers for Disease Control and Prevention (CDC) established the National Nosocomial Infection Surveillance System (NNIS) in 1970. This National Nosocomial Infection Surveillance System (NNIS) in between 1986-1996 reported that 15,523 surgical site infection (SSI) made the 593,344 cases of operations complicated. In which, two-thirds were incisional, and one-third were found to be organ/space infections. In the report it is stated that 77% of the deaths in patients with nosocomial surgical site infection (SSI) were infection related and the majority were serious infection related which involves the organs or spaces accessed during the operation.[15-18]

In the surgical procedure, there always bears a risk of surgical site infection (SSI). The surgeon performing the surgical operation deals with infection in three ways, firstly a condition where infection already exists, secondly when the presence of significant factors required for infection are already there and thirdly where surgery is performed for some disease not related to infection and this surgery leads to predisposition to infection.[19, 20-22] It was also observed many times earlier by other researchers that increased preoperative hospital stay lead to higher incidence of surgical site infections (SSIs).[19-21]

In cases of surgical site infection (SSI) the common pathogens responsible for surgical site infection (SSI) are Staphylococcus aureus, Enterococcus spp. and Escherichia coli.[8, 22] Pathogens that cause SSI may derive from the patient’s own microbial flora on the skin and in the body, or from the skin or mucous membranes of operating personnel, or from the operating room environment (including air), and the instruments and tools used during the procedure. Occasionally, micro-organisms from a distant infection in the body can establish an SSI by attaching to a prosthesis or other implant left in the operative site. Certain patient related conditions which lowers the efficacy of the immune response and delays wound healing such as diabetes, malnutrition, smoking, obesity, alcoholism, extremes of age, steroid therapy, chemotherapy, radiotherapy, Peripheral vascular disease, skin disease at operation site, pre-existing infection, chronic inflammatory conditions increase the risk of acquiring surgical site infection (SSI).[14]

### 2. CLASSIFICATION OF SURGICAL SITE INFECTIONS

According to Centers for Disease Control and Prevention (CDC) surgical site infection (SSIs) are classified as:

#### 2.1. Incisional SSI:
In incisional surgical site infection (SSIs) being further sub classified as:
- Superficial (involving only skin and subcutaneous tissue)
- Deep (involving underlying soft tissue).

#### 2.2. Superficial Incisional SSI:
Infection that occurs within thirty days after the operation and infection involves only skin or subcutaneous tissue of the incision and at least one of the following:

1. Purulent drainage, with or without laboratory confirmation, from the superficial incision.
2. Organisms isolated from an aseptically obtained culture of fluid or tissue from the superficial incision.
3. At least one of the following signs or symptoms of infection: pain or tenderness, localized swelling, redness, or heat and superficial incision is deliberately opened by surgeon, unless incision is culture-negative.
4. Diagnosis of superficial incisional SSI by the surgeon or attending physician.

**Do not report the following conditions as SSI:**

1. Stitch abscess (minimal inflammation and discharge confined to the points of suture penetration).
2. Infection of an episiotomy or newborn circumcision site.
3. Infected burn wound.
4. Incisional SSI that extends into the fascial and muscle layers (see deep incisional SSI).

Note: Specific criteria are used for identifying infected episiotomy and circumcision sites and burn wounds.[14, 25, 26]

#### 2.3. Deep Incisional SSI:
Infection occurs within 30 days after the operation if no implant is left in place or within one year if implant is in place and the infection appears to be related to the operation and infection involves deep soft tissues (eg, fascial and muscle layers) of the incision and at least one of the following:

1. Purulent drainage from the deep incision but not from the organ/space component of the surgical site.
2. A deep incision spontaneously dehisces or is deliberately opened by a surgeon when the patient has at least one of the following signs or symptoms: fever (≥38°C), localized pain, or tenderness, unless site is culture-negative.
3. An abscess or other evidence of infection involving the deep incision is found on direct examination, during reoperation, or by histopathologic or radiologic examination.
4. Diagnosis of a deep incisional SSI by a surgeon or attending physician.[14, 25, 26]

#### 2.4. Organ/Space SSI:
Infection occurs within thirty days after the operation if no implant is left in place or within one year if implant is in place and the infection appears to be related to the operation and infection involves any part of the anatomy (eg, organs or spaces), other than the incision, which was opened or manipulated during an operation and at least one of the following:
1. Purulent drainage from a drain that is placed through a stab wound\(\dagger\) into the organ/space.

2. Organisms isolated from an aseptically obtained culture or fluid or tissue in the organ/space.

3. An abscess or other evidence of infection involving the organ/space that is found on direct examination, during reoperation, or by histopathologic or radiologic examination.

4. Diagnosis of an organ/space SSI by surgeon or attending physician.\(^{[14, 25, 26]}\)

### 3. EFFECTS OF SURGICAL SITE INFECTION

Surgical site infections (SSIs) are the most common cause of nosocomial infection after urinary tract infections (UTI) covering approximately 17% of all hospital acquired infections\(^{[20]}\) and lead to increased costs and worsen the patient outcomes in hospital inpatients.\(^{[29]}\) For surgical patients, surgical site infections (SSIs) are very common nosocomial infection and also have been a leading cause of operation-related adverse events.\(^{[27-29]}\) Less studies are done in India in this direction.\(^{[14]}\) The Centers for Disease Control and Prevention (CDC) estimates that approximately 500,000 SSIs occur annually in the United States.\(^{[46]}\) When surgical patients with surgical site infection (SSI) died, 77% of the deaths were reported as related to the infection and the majority (93%) were serious infections involving organs or spaces accessed during the operation.\(^{[12, 29]}\)

Increase in costs and outcomes of surgical site infections (SSIs) can vary by location and surgery type. Patients with SSIs are more likely to require readmission to hospital or intensive care unit (ICU) treatment.\(^{[30, 31]}\) Overall, surgical site infections (SSIs) may result in elevated direct and indirect medical costs each year.\(^{[23, 24]}\) Surgical site infection (SSI) impose a clinical burden, and are at higher risk of death, than those without such infections. For example, in a case control study involving 215 matched pairs of patients with and without SSIs, the relative risk for death associated with SSIs was 2.2 [95% confidence interval (CI): 1.1 4.5], and those for readmission and ICU treatment were 5.5 (4.0 7.7) and 1.6 (1.3 2.0), respectively. Moreover, patients with SSIs required longer hospitalisation the median duration of hospitalisation in infected patients was 11 days, compared with 6 days in uninfected patients, and the median extra duration attributable to SSIs was 6.5 days (95% CI: 5 8). Similarly, a review of the incidence and health economic implications of SSIs in Europe found that the mean length of extended hospitalisation was 9.8 days. As a result, SSIs causes considerable increases in healthcare costs. In the case control study described above, the median excess cost associated with SSIs during a first hospitalisation was $3089 (95% CI: $2139 4163), and this figure increased to $5038 in patients who required readmission. Similarly, European data suggest that the mean cost of prolonged hospitalisation due to SSIs is €325 per day.

Deep SSIs involving organs or body spaces are associated with even longer prolongations of hospitalisation, and further increases in costs, compared with SSIs that affect only the incision.\(^{[8, 34, 35]}\)

### 4. PREVENTION OF SURGICAL SITE INFECTION

Practices to prevent SSI are aimed at minimising the number of microorganisms introduced into the operative site, for example:

1. Removing micro-organisms that normally colonise the skin

2. Preventing the multiplication of micro-organisms at the operative site using prophylactic antibiotics

3. Enhancing the patient’s defence mechanism against infection, for example by minimising tissue damage and maintaining normal body temperature during the surgical duration

4. Preventing access of microorganisms into the incision postoperatively by use of a wound dressing.\(^{[36]}\)

Preventive management of SSIs is based largely on using evidence-based guidelines that support a safe patient environment during the perioperative period. The Surgical Care Improvement Project (SCIP) is a national quality partnership of organizations committed to improving patient safety by promoting evidence-based interventions as the standard of care to minimize the incidence of surgical complications. Efficacy and implementation of SCIP measures are supported by the literature. Most SSIs result from bacterial inoculation at the time of surgery, even though infection presentation manifests several days later. The anesthesia provider can make a substantial contribution to prevention of SSIs during the perioperative period by implementing the SCIP guidelines for timely and appropriate use of antibiotics and maintenance of normothermia.\(^{[10, 37]}\)

Some of the most common preventive measures of surgical site infections are discussed below:

#### 4.1. Hypothermia:

Adverse outcomes of hypothermia include increased blood loss and transfusion requirements, prolonged postoperative recovery times, heightened postoperative pain, and impaired immune function. Hypothermia compromises neutrophil function and promotes vasoconstriction, which leads to tissue hypoxia and increased incidence of SSIs.\(^{[10, 37]}\)

#### 4.2. Preoperative phase:

Preoperatively, attention should be paid to prevent the in infection by ensuring appropriate glycaemic level in diabetics, stopping smoking, improving nutritional status and checking and correcting anaemia. All patients should take bath with soap on night prior to or the day of operation.\(^{[14]}\)
4.3. Hair removal
The centre for disease control and prevention (CDC) recommended that hair should not be removed unless it will interfere in the operation, and if hair need to be removed it is done immediately before the operation with electric clippers rather than shaving. Shaving by razor results in microscopic cuts and abrasions, as a result can cause disruption of the skin’s barrier defense against microorganism colonization and increase the risk of postoperative surgical site infection (SSI).[14, 38, 39]

4.4. Appropriate use of antibiotics:
Preoperative antibiotic prophylaxis should be given to patients undergoing clean surgery involving the placement of a prosthesis or implant, clean-contaminated surgery and contaminated surgery.[14, 40, 41] Based on published evidence, the SCIP established that an antibiotic received prophylactically within one hour before incision reduces the risk of infection. When a fluoroquinolone or vancomycin is the indicated antibiotic, administration should occur within 120 minutes before incision to avoid an adverse reaction associated with rapid infusion. Appropriate antibiotic selection is based on recommended guidelines for procedures targeted for national surveillance. Although research demonstrates that many antibiotic regimens are effective preventive agents, the professional consensus supports using narrow-spectrum, first- and second generation cephalosporins, which are inexpensive, safe to use, and bactericidal, and have long half-lives.[10, 37]

4.5. Hand Hygiene:
Numerous studies have proved that healthcare professional hands transmit microorganisms to patients. Evidence proves that effective hand washing is the cornerstone for preventing healthcare-associated infections. It is also important in preventing specific site infections such as catheter-related bloodstream infections, catheter-related urinary tract infections, ventilator-associated pneumonia, and SSIs.[10, 37]

4.6. Patient theatre wear:
Specially designed gown or theatre wear should be given to patients undergoing surgery that allow easy access to the operative site as well as other areas for placement of intravenous cannulas, catheters and surgical process needed etc. The operating team should remove hand jewellery, artificial nails and nail polish before operation.[14, 42]

4.7. Intraoperative phase:
Skin antiseptics are used in reduction of skin microflora around the incision. Before performing surgery prepare the skin at the surgical site immediately before incision using an antiseptic. Chlorhexidine or providone-iodine are the most suitable antiseptic used in surgeries. This preparations are effective against a wide range of gram-positive and gram negative organisms in combination with alcohol based solutions. Alcohol is rapidly bactericidal, but once evaporated, it has no persistent antimicrobial effect. Thus, alcohol should be combined with either iodine or chlorhexidine in surgical preparations. Optimal oxygenation and good hydration should be maintained during surgical process. Patient should be provided with sufficient oxygen during surgery and in the recovery period so that a haemoglobin saturation of more than 95% is maintained.[14, 43]

4.8. Perioperative blood glucose control:
Elevated blood glucose levels cause the release of pro-inflammatory cytokines that depress the immune system, thus increasing susceptibility to surgical site infection (SSI).[8, 53] Appropriate glycemic control during the first 48 hours of surgery has been shown to help to reduce many surgical site infections (SSIs) in cardiovascular surgery and surgical ICU patients.[8, 54] Also, hyperglycemia (>200 mg/dL) has been associated with increased SSI risk in the immediate postoperative period.[14, 43]

4.9. Wound closure and wound dressings:
Wound dressing material should be such that the wound remains moist, free from toxic chemicals and other particles released from the dressing material.[14]

4.10. Postoperative phase: Proper and regular cleansing of the wound and surrounding area is necessary for the removal of excess wound exudates, foreign bodies.[14]

5. TREATMENT
Minor infections may respond to drainage of pus after removal of sutures and topical antisepsis. In clinically serious infections, microbiological cultures should be sought and antibiotic therapy is given according to results of drug sensitivity testing. Unnecessary antibiotic therapy carries the risk of development of drug resistance and adverse drug reactions.[14, 43]

Principal (category 1) recommendations of the Centers for Disease Control and Prevention (CDC) guidelines for surgical site infection (SSI) prevention[8]:

5.1. Preoperative
Preparation of the patient
(1) Where possible, identify and treat remote infections, and postpone surgery until such infections have resolved (1A)
(2) Do not remove hair around the operation site, unless it will interfere with the operation (1A)
If hair is removed, this should be done immediately before the operation, preferably with clippers (1A).

Adequately control blood glucose in diabetic patients, and avoid perioperative hyperglycaemia (1B).

Encourage tobacco cessation (1B).

Do not withhold necessary blood products as a means of preventing SSIs (1B).

Require patients to shower or bathe with an antiseptic agent on at least the night before the operation (1B).

Thoroughly wash and clean around the incision site to remove gross contamination before performing antiseptic skin preparation (1B).

Use an appropriate antiseptic for skin preparation (1B).

5.2. Hand/forearm antisepsis for surgical team members

Keep nails short and do not wear artificial nails (1B).

Perform preoperative surgical scrub for at least 2 5 min using an appropriate antiseptic. Scrub hands and forearms up to the elbows (1B).

After performing the surgical scrub, keep hands up and away from the body (elbows flexed). Dry hands with a sterile towel and don sterile gown and gloves (1B).

5.3. Management of infected or colonised surgical personnel

Educate and encourage surgical personnel who have signs and symptoms of transmissible infectious illness to report conditions promptly to their supervisors and occupation health service (1B).

Develop well-defined policies concerning patient care responsibilities when personnel have potentially transmissible infectious conditions (1B).

Obtain appropriate cultures from, and exclude from duty, surgical personnel with draining skin lesions until infection has been ruled out or resolved (1B).

Do not routinely exclude personnel who are colonised with organisms such as S. aureus or Group A Streptococci unless such personnel have been linked epidemiologically to dissemination of the organism in the healthcare setting (1B).

5.4. Antimicrobial prophylaxis

Administer antimicrobial prophylaxis only when indicated and select agent according to efficacy against most common pathogens associated with a specific procedure (1A).

Administer initial dose intravenously, timed so that bactericidal concentrations are established in serum and tissues when incision is made. Maintain therapeutic concentrations in serum and tissue throughout the procedure until at most a few hours after wound closure in the operating theatre (1A).

Before elective colorectal operations, mechanically prepare the colon by use of enemas and cathartic agents. Administer non-absorbable oral antimicrobial agents in divided doses on the day before the operation (1A).

For high-risk caesarean section, administer prophylaxis immediately after the umbilical cord is clamped (1A).

Do not routinely use vancomycin for antimicrobial prophylaxis (1B).

5.5. Intraoperative

5.5.1. Ventilation

Maintain positive pressure in the operating theatre with respect to corridors and adjacent areas (1B).

Maintain at least 15 air changes per hour, of which three should be fresh air (1B).

Filter all air, recirculated and fresh, through appropriate filters (1B).

Introduce all air at the ceiling, and exhaust near the floor (1B).

Do not use UV radiation in the operating theatre to prevent SSI (1B).

Keep operating theatre doors closed except as needed for passage of equipment, personnel, and the patient (1B).

5.5.2. Cleaning and disinfection of environmental surfaces

When visible soiling or contamination with blood or other body fluids of surfaces or equipment occurs during an operation, clean affected areas with disinfectant before the next operation (1B).

Do not perform special cleaning or closing of operating theatres after contaminated or dirty operations (1B).

Do not use tacky mats at the entrance to the operating suite or theatre for infection control (1B).

5.5.3. Microbiological sampling

Do not perform routine environmental sampling of the operating theatre. Perform microbiological sampling of operating theatre environmental surfaces or air only as part of an epidemiological investigation (1B).

5.5.4. Sterilisation of surgical instruments

Sterilise all surgical instruments according to published guidelines (1B).

Perform flash sterilisation only for patient care instruments that will be used immediately (e.g. to reprocess a dropped instrument).
5.5. Postoperative incision care

(1) Protect an incision that has been closed primarily with a sterile dressing for 24-48 h postoperatively (1B)
(2) Wash hands before and after changing dressings and any contact with the surgical site (1B) Surveillance
(1) Use CDC definitions of SSI without modification for identifying SSI among surgical inpatients and outpatients (1B)
(2) For inpatient case-finding (including readmissions), use direct prospective observation, indirect prospective detection, or a combination of direct and indirect methods for the duration of hospitalisation (1B)
(3) For outpatient case-finding, use a method that accommodates available resources and data needs (1B)
(4) For each patient undergoing an operation chosen for surveillance, record those variables shown to be associated with increased SSI risk (e.g. surgical wound class, duration of operation, etc.) (1B)
(5) Periodically calculate operation-specific SSI rates stratified by variables shown to be associated with increased SSI risk (e.g. NNIS risk index) (1B)
(6) Report appropriately stratified, operation-specific, SSI rates to surgical team members. The optimum frequency and format for comparisons of SSI rates will be determined by stratified case-load rates and the objectives of local continuous quality improvement initiatives (1B)

Category 1 recommendations are 'strongly recommended for implementation', and are supported by well designed clinical, or epidemiological studies; category 1A and 1B recommendations differ only in the strength of the supporting evidence. [2]

6. CONCLUSION:
After reviewing several articles on surgical site infections (SSIs) it is identified that SSIs are the most common of the nosocomial infections or hospital acquired infections. The SSIs have large clinical and economic impacts on patients and health care organizations. Although, SSIs are easily preventable therefore, efforts should necessarily focus on prevention. Clearly, preventing SSI is a complex process requiring a multidisciplinary approach that depends on the expertise of various professional groups. Implementing multidisciplinary strategies in SSI prevention must be consistently applied as per the needs of the individual patient and health care organization. This review has identified that using a bundled approach, sharing responsibility, and adhering to best practice are strategies used by health care professional teams in the prevention of SSI.

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