

Preventive Strategy for Surgical Site Infections in Orthopaedics

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Abstract

Surgical site infections are serious complication of any surgery. There are many factors that affect the incidence of surgical site infections and if these factors are understood and controlled to a certain extent, it will help in reducing the incidence of SSIs. In current review, an overview of patient factors, Operative set up and intraoperative precautions are presented which will help in understanding and preventing SSIs

Keywords: Surgical site infection, Orthopaedics, Prevention

Introduction:

Surgical Site infection (SSIs), although uncommon, constitute a major challenge to medical teams and health care institutions. The burden of this problem weighs heavily on both the surgeon and the patient. To reduce the burden of these infections, a partnership of national organizations in the USA, including the Centers for Medicare and Medicaid Services and the Centers for Disease Control and Prevention, created the Surgical Care Improvement Project (SCIP) and developed various infection prevention measures. They deemed SSI as a "NEVER EVENT", so that reimbursements to institutions are heavily affected for patients that develop SSIs. Infection prevention strategies are multipronged and efforts have shifted towards the preoperative setting. These focus on the patient and their potential risks (both modifiable and non-modifiable), for postoperative complications. A 'bundle' approach, with systematic attention to multiple risk

factors, in order to reduce the risk of bacterial contamination and improve the patient's defence is deemed most appropriate.

This article is intended to give a summary of different preventive strategies to minimize the risk of Surgical Site Infection (SSI). The article is divided into:

1. Patient related factors
2. Pre-operative patient preparation techniques and Operation Room (OR) set-up and discipline
3. Intra-operative techniques to decrease SSI

These protocols are not exhaustive but they are an outcome of global consensus meetings and existing literature aimed at decreasing SSI.

1. Patient Related Factors

Patient dependent risk factors are classified as modifiable such as diabetes, obesity, smoking, alcohol consumption, malnutrition and nasal carriage of *S. aureus*. Non-modifiable risk factors include age > 65 years, AIDS, rheumatoid arthritis, corticosteroid therapy and recent radiotherapy at the operative site.

Does Diabetes mellitus increase SSI?

It is reported that pre-operative

blood glucose >125 mg/dl or postoperative blood glucose >200 mg/dl are independent risk factors for SSI {Odds Ratio 3.5 (P= 0.004) and 3.3 (P< 0.001)} respectively[1]. Hikata et al. reported that 6 patients out of 36 (16.7%) with DM had a post-operative wound infection, compared to 10 SSIs out of 309 (3.2 %) patients without DM. The perioperative serum glucose level did not differ between DM patients that did or did not develop SSI but the preoperative HbA1c value was significantly higher in the patients who developed SSI. None of the patients with controlled diabetes (HbA1c < 7.0) suffered a SSI, while wound infections were observed in 35.3 % of patients with uncontrolled diabetes[2].

Does obesity predispose to SSI?

Obesity is linked to higher SSI rates. In these patients, surgery is more difficult, longer, and there is more bleeding. A much wider dissection of adipose tissue is necessary, and the resulting necrosis is a favorable environment for infection. In a meta-analysis of 34 articles reporting the impact of increased Body Mass Index (BMI) on SSI, Abdallah et al reported an adjusted increase in SSI of 21 %, for every 5 unit increment in BMI[3].

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Does Smoking increase SSI?

Smoking leads to delayed wound healing due to decreased tissue oxygenation and a diminished inflammatory response. Pahys et al identified smoking as an independent risk factor of SSI. They noted that smokers had an odds ratio of 2.6 for SSI (P= 0.008)[4]. Smoking cessation has been shown to decrease the risk of SSI, but it must be done at least 4 weeks prior to surgery [5].

Does poor nutrition influence SSI?

Adequate preoperative nutrition is vital for sound wound healing. Klein et al noted that serum protein < 6g/dl, albumin levels of < 3.5 g/dl, and total lymphocyte count of < 1500 cells/ mm³ were significantly associated with SSI [6].

Does MRSA colonization of personnel increase SSI?

The prevalence of healthcare worker MRSA colonization is estimated to be between 4.6 and 7.9% [7-9]. 41% of nosocomial infections of MRSA (including all pathogens) transmitted by a contaminated staff member occurred in the OR [10]. Several studies have proven that decolonization of contaminated staff members and patients and adding a broad spectrum antibiotic to their surgical prophylaxis decreases the SSI manifolds. [11,12]

Rheumatoid Arthritis & DMARDs:

The influence of a patient's treatment is essential in cases of highly inflammatory rheumatic diseases. It is not recommended to stop corticosteroid treatment at the time of surgery because of a risk of acute adrenal insufficiency. Continued treatment with methotrexate does not increase the risk of SSI. Data on continuing or stopping anti-TNF are still lacking. It is generally recommended to stop anti-TNF treatment from two to five half-lives before surgery and until the skin wound has completely healed. This treatment must be stopped when

infection of instrumentation is diagnosed.

2. Pre-operative Strategy and Operation Room Protocols to decrease SSI:**Does skin cleansing at home decrease SSI?**

As noted by the Centers for Disease Control and Prevention, preoperative skin cleansing with an antiseptic agent can substantially decrease skin microbial counts [13,14]. According to literature, pre-operative Chlorhexidine bathing reduces the risk of SSI.

Does Pre-op Hair Removal decrease SSI?

Meta-analysis by Tanner et al in 2006, found electric clippers and depilatory creams to be associated with lower rates of SSIs in comparison to shaving with a razor blade [15]. Increased lengths of time to complete chemical depilation and the potential risk for chemical irritation of the skin make its utilization less advantageous [15-17]. Hence, it is highly recommended that hair depilation be completed with an electric clipper [18]. If hair removal is to be done prior to surgery, it should be completed as close to the time of surgery as possible by either the surgical team or the trained nursing staff [16,17], preferably outside the OT.

Does a second skin cleansing after sterile surgical draping decrease SSI?

It has been hypothesized that bacteria may be reintroduced to the surgical site during this draping process [19]. There has been only one prospective study by Morrison et al. There were significantly lower rates of superficial SSIs in the patients who were cleansed with iodine and isopropyl alcohol after draping. However, no significant differences were noted in the incidence of overall SSIs (both superficial and deep).

What skin preparation solution is most effective?

The ideal skin preparation solution needs to work rapidly and also prevent the growth of pathogens for at least six hours after application [16]. Available skin prepping solutions used preoperatively to prevent SSIs include: iodine povacrylex and isopropyl alcohol, Povidine Iodine (PI), Chlorhexidine gluconate (CHG) and isopropyl alcohol [20,21]. In a Cochrane review by Dumville et al. on skin antiseptics, the following points were concluded:

1. No statistically significant differences between skin preparation with PI and soap followed by methylated alcohol paint.
2. No differences between 7.5% aqueous povidone in 10% alcohol and CHG in 70% alcohol paint.
3. 0.5% chlorhexidine in methylated spirit had reduced risk of SSIs compared with PI in alcohol (one study only, with poor reporting of details).
4. No significant differences in number of SSIs when comparing aqueous and alcoholic solutions for skin preparations. The current literature lacks evidence to support the use of one solution over another in the prevention of SSIs, but there is an overall consensus that skin preparation solutions should contain alcohol.

Does using disposable/ Non-disposable drape affect SSI?

There is a paucity of literature relating specifically to orthopaedic surgery on this topic. Randomized controlled trials in cardiac and general surgery demonstrated no statistically significant differences in infection rates between the two types of drapes [22,23]. This topic is inconclusive, as far as orthopaedic or spine surgery is concerned.

Does Use of Surgical Incise Draping (OPSITE/IOBAN) decrease SSI?

In a recent Cochrane review of 3,082 patients, Webster et al. found that a

higher proportion of patients developed surgical site infections with plastic drapes than patients in whom no drapes were used ($p = 0.03$) [24]. However, no difference was found when iodophor-impregnated drapes were used (1.03, 95% confidence interval (CI) 0.06 to 1.55, $p = 0.89$). There is a need for more studies evaluating the effect of iodine-impregnated incise drapes on infection rates.

Does Use of Sterile Stockinettes and Foot preparation decrease SSI?

The efficacy of non-woven drapes in preventing contamination has been proven [25], including an impervious stockinette. As per the study by Marvil et al. in 2014, when non-pathogenic *E. coli* was applied to feet of cadavers and compared between the chlorhexidine prepared versus the unprepared foot with an impervious stockinette to mid-thigh level. Bacterial contamination at various sites including foot, ankle, 12 cm, 24 cm and 36 cm proximal to the ankle were assessed. In the non-prepared foot group, significant contaminations, as proximal as 24 cm to the ankle joint, were found, whereas no contaminations were found at any site in the prepared group [26].

OT Personnel Traffic, Door Openings (DO) and SSI:

Ritter et al. [27] reported that the bacterial counts were 34-fold higher when 5 or more persons were present, compared to an empty OR. Weiser et al. [28] reported that positive pressure was not defeated during any single Door Opening (DO), however they found that contaminated outside air entered the OR if two doors were simultaneously opened. In their study, OR pressure recovery took approximately 15 seconds following a DO. They supported that OR contamination was more likely attributable to the effects of the personnel who enter the OR rather than as a primary cause of DOs.

Hand Scrubbing and SSI:

A Cochrane database review that was published in 2016 concluded that there is no firm evidence that one type of hand antisepsis is better than another in reducing SSIs [29]. Chlorhexidine gluconate scrubs may reduce the number of Colony Forming Units (CFUs) on hands compared with povidone iodine scrubs. Alcohol rubs with additional antiseptic ingredients may reduce CFUs compared with aqueous scrubs [29]. A three-minute scrub reduced CFUs on the hand compared with a two-minute scrub but this was very low-quality evidence.

Ideal cap to be used by Surgical personnel:

Markel et al. found that there were significantly higher numbers of airborne particulates when disposable bouffant hats were used compared to cloth surgical caps ($p < 0.05$) [30]. However, there is no common consensus and more research is needed on this issue.

Coverage of Facial hair/ beard in reducing SSIs:

In a study by McLure et al., it was recommended to avoid behaviors that encourage unnecessary face mask movement and concluded that it may be advisable to remove facial hair in an operative environment due to the potential risk of bacterial shedding [31]. As an alternative to facial hair removal, non-sterile surgical hoods used alongside face masks may be considered.

Does wearing OT attire outside designated OR area increase SSI?

There is little to no concrete evidence showing that wearing OR attire in external, unrestricted hospital environments and returning without changing increases SSIs and the rates of wound infections [32]. But until conclusive evidence is brought forth, OR attire worn outside the operating room remains a potential source for surgical contamination.

Does Laminar Airflow Decrease SSI?

There is evidence showing that use of Laminar air-flow does not affect SSI [33,34] and some studies also show that there is an increase in SSI after using laminar airflow [35-37]. The major drawback of the laminar airflow is that they fail to address the environment outside of the immediate laminar flow zone. Standard vertical laminar systems only treat about a 3m² area, leaving very little room for implant and instrument trays and tables. Unfortunately, laminar systems may actually contribute to the contamination of these areas by blowing bacteria off of personnel and the floor, onto instrumentation and other personnel [38]. Further studies are needed to validate the use of Laminar air-flow.

Does Use of Warmers (Forced Air Warming) affect SSI?

The current literature is not conclusive enough to state that use of forced air warmers or conductive fabric warming increases SSI [39-42].

Are OT Lights a source of SSI?

There is no supporting evidence or prognostic studies that have linked the contamination on the light handles to patients developing subsequent SSI with the same source contaminant [43]. But contamination of light handles cannot be ruled out and hence due precautions need to be taken during surgery.

3. Intra-operative steps to decrease SSI:

Does Changing of surgical gowns, gloves decrease SSI?

There is a time dependent contamination of trays during surgery, 4% of trays contaminated at 30 minutes, 15% contaminated at one hour, 22% at 2 hours, and 30% at 4 hours [44]. Kaya et al. performed a study with a similar scope and determined that glove perforation

occurred approximately every 90 minutes during surgery [45]. Hence, gloves should be changed at this interval. Bible et al. found that after an average duration of 134 minutes the contamination rate of impermeable disposable gowns ranged from 6 to 48% depending on location. The highest levels of contamination were at the shoulders (48%) and the bottom of the gown (26%) and the least contamination at the level of the chest (6%) [46]. Hence, longer duration of surgery, does predispose to SSI.

Does changing Electrocautery tips decrease SSI?

Abdelaziz et al. looked at both primary and revision hip and knee arthroplasties. This study revealed a higher rate of electrocautery tip contamination in their primary arthroplasty cohort [47]. Given the high rates of contamination noted during septic cases, changing the electrocautery tips prior to implantation of components is recommended.

Does changing Suction Tips decrease SSI?

Several studies reported contamination rates of suction tips as high as 37 to 65% in conventional/non-laminar air operating theaters [48,49] and 4.6 to 41% in ultra-clean/laminar flow operating theaters [50]. Staphylococcus species (coagulase-negative and epidermidis) were the dominating contaminants isolated from suction tips, comprising 34 to 100% of cases [48,50].

Suction machines should be turned on as late as possible to decrease the contamination.

Should blades be changed to decrease SSI?

Due to lack of strong evidence, it is advocated to maintain the conventional surgical technique of changing the skin scalpel, and continue to deeper planes with a new blade. [51,52]

Does increased Operative time increase SSI?

In a retrospective study on patients undergoing TKA, an operative time of >90 minutes was found to have higher incidence of SSIs and PJI's (2.1 and 1.4%,) compared to cases lasting 60 to 90 minutes (1.1 and 0.7%), and those lasting ≤ 60 minutes (0.9 and 0.7%) [53]. Longer the duration of surgery, more is the risk of SSI.

Conclusions

An important commandment within the Hippocrates oath administered to physicians and surgeons is, "First, Do No Harm". SSIs are devastating complications that compromise the outcomes of surgery and may result in chronic pain, disability and loss of function. Hence medical practitioners and health care institutions must make all efforts to reduce the risk and prevent SSIs. This involves a multipronged strategy that involves constant vigilance

and application of infection prevention bundles, both preoperatively and intraoperatively within the operation theatre. Strategies for preventing wound infections take into account the host characteristics and risks, the technique of procedure, protective garb for staff, preparation of the patient, wound closure methods, the operating theater environment, and the disinfection and sterilization of the surgical instruments and supplies.

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