

## Surgical Site Infection, Prevalence, Management and Prevention

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### Abstract

**Background:** Postoperative wound infection or Surgical Site Infection (SSI) is defined as wound infection occurring within 30 days of the operative procedure or within one year if the implant is left in place and the infection is considered to be secondary to the operation. SSIs can range from a relatively trivial wound discharge to a life-threatening condition without any other complications. SSI is one of the most common health-care-associated infections and may occur in 5 - 20% after surgery.

**Aim:** In this review, we will look into epidemiology, risk factors, management and prevention of surgical site infection.

**Conclusion:** There is a profound effect of SSIs on both patients and healthcare organizations; hence efforts should be focused on implementing complex multidisciplinary prevention strategies. Knowledge of the important consequences of SSI for patient safety and treatment costs is of prime importance to any surgeon and tracking one's own activities in the operating room in relation to existing literature is an essential step in preventing infection and optimizing beneficial outcomes.

**Keywords:** COVID-19; SARS-CoV2 (Severe Acute Respiratory Syndrome Coronavirus2); Infectious Diseases

### Introduction

Postoperative wound infection or Surgical Site Infection (SSI) is defined as wound infection occurring within 30 days of the operative procedure or within one year if the implant is left in place and the infection is considered to be secondary to the operation [1]. With the advent of systemic, perioperative antimicrobials, natural host defenses were reinforced and the ability to perform more complicated operations was greatly enhanced. SSI is one of the most common health-care-associated infections and may occur in 5 - 20% after surgery [2]. In different types of surgery, the rates of infection ranged from 5.3% in clean operations to 47.6% in dirty operations. About one third of the infections have been categorized as moderate or severe [3]. SSIs can range from a relatively trivial wound discharge to a life-threatening condition without any other complications. Other clinical outcomes of SSIs include poor cosmetically unacceptable scars such as those that spread, hypertrophic or keloid, persistent pain and itching, restriction of movement, especially when over joints and a significant impact on emotional wellbeing [4].

There are various factors that contribute to the risk of occurrence of SSI and preventive measures require an integrative approach that focuses through pre-, intra- and post-operative care involving all the stakeholders [5]. The risk of such infections is determined by technical operational problems, noticeably bleeding, the amount of devitalized tissue created and the need for drains within the wound, as well as metabolic factors such as obesity and diabetes [2].

The causative pathogens depend on the type of surgery; the most commonly isolated organisms are *Staphylococcus aureus*, coagulase-negative *Staphylococci*, *Enterococcus* spp. and *Escherichia coli* [2]. The optimal reduction of SSIs remains a challenge, despite several procedural advances. To date, most SSI preventive interventions have centered on the surgical team with patient participation intervention on SSI prevention, and it remains to be measured the efficacy of this strategy [6]. Prevention of postoperative wound infection is done by good general hygiene, operative sterility and effective barriers against transmission of infections, before, during and after surgery [7]. The skill of the surgeon and his ability to prevent the formation of fluid collections, limit the extent of residual devitalized tissue, and achieve the prompt removal of drains and devices that traverse and potentially injure the primary mucocutaneous barrier is an important preventive way of SSI [8]. Basic guidance from hospital management, expertise and ability of surgical staff, adequate equipment, excellent treatment of full patient admission and post-discharge monitoring of patients will lead to substantial reduction of SSIs, lower mortality rates and a less costly health care system [2]. Aggressive surgical debridement and effective antimicrobial therapy are needed to optimize the treatment of SSI [9].

In this review, we will look into epidemiology, risk factors, management and prevention of surgical site infection.

### Epidemiology

The incidence of SSIs may be as high as 20% and they are believed to increase the risk of dying 2 - 11 folds [10], with 77% of these deaths attributed directly to the infection [11]. Data from low and middle-income countries showed an overall incidence rate of 5.6% [12], whilst 2.6% reported in the USA (Approximately 160,000 - 300,000 SSIs occur each year in the United States) [13,14], 1.6% in Germany [15], 1.4% to 38.8% in Brazil based on data on the incidence of SSI in general and specific surgeries [16], 2.8% in Australia [17], 1.26% in France [18] and 1.5 - 20% of operations may result in SSI in Europe [19]. After general surgery, with one postoperative infection, the risk of death may be 7.5%, and if there are more hospital infections in the patient at the same time, the risk of death may increase to 17.1% [20].

### Risk factors

There are several well-documented risk factors for SSIs but they can also be mixed, combined, intermittent, unrecorded and difficult to identify [21]. Risk factors may be microbe-related risk factors, with *Staphylococcus aureus* and *Streptococcus pyogenes* being particularly virulent; host-related risk factors, with morbid obesity, an index of disease severity, old age, malnutrition, diabetes, cancer and systemic infection and operation-related risk factors, including prolonged hospital stay before surgery, duration of the operation, tissue trauma, poor hemostasis and foreign material in the wound, with these last greatly increasing the risk of serious infection despite a relatively small bacterial inoculum [22].

Surgical wounds are traditionally classified into four classes based on how clean or contaminated they are according to the CDC definition as clean wound (infection risk < 2%, e.g. laparotomy, breast resection, vascular interventions), clean/contaminated wound (infection risk < 10%, e.g. elective cholecystectomy, small bowel resection, laryngectomy), contaminated wound (risk infection of about 20%, e.g. appendiceal phlegmon, gangrenous cholecystitis), dirty/infected wound (risk infection > 40%, e.g. infected traumatic wounds, pus collections such as testicular abscess) [23].

Risk for SSIs depends on amount of bacteria in the wound, virulence and antibiotic resistance, tissue damage around the wound, foreign material in the wound, the patient's general condition and local immunity, and antibiotic prophylaxis [24].

### Microbiology

In the majority of SSI cases, the pathogen source is the native flora of the patient's skin, mucous membranes, or hollow viscera. The

heavy skin flora and liberation of skin particles from bare skin must be considered when working with sterile procedures, with infection-susceptible patients, surgical activity, wound care and care of drains and intravascular equipment [25]. SSI is most frequently caused by *S. aureus*. Other causative microbes are *Escherichia coli*, *Klebsiella* sp., *Enterobacter cloacae*, *Pseudomonas* species, etc. and enterococci and anaerobic bacteria [26]. The skin is protected as long as it is intact. Normal skin flora represents coagulase-negative *Staphylococci*, dominated by *Staphylococcus epidermidis*,  $10^3$ - $4$  per  $\text{cm}^2$ . About 25% of *S. aureus* in surgical wounds comes from operating personnel, 25% from the patient and the rest from environment, pre-, per- or postoperatively. *S. epidermidis* is related to airborne transmission [27].

In recent years, the proportion of resistant pathogens such as methicillin-resistant *S. aureus* (MRSA) has increased. MRSA is the worst of all bacteria and the leading cause of fatal nosocomial infections in the United States [28]. MRSA-caused SSIs contributed to 16 extra days in hospital, 13.5% raise in discharge to long-term institutions, about 70% more frequent readmissions and 14% higher mortality rates than in surgical patients without SSIs [29]. *Candida* can be significant with prolonged antibacterial therapy. *S. aureus* is an increasing problem and especially resistant *S. aureus* as MRSA [30].

### Management of surgical site infection:

To help elucidate the extent and location of the infection, rapid assessment with a history and physical examination should be supplemented with imaging. Source control will in the majority of cases be guided by image findings [31].

Most SSIs respond to suture removal with pus drainage if present, and occasionally, debridement and open wound care are required. Suitable management of developed SSIs involves constant monitoring and coordination between the post-operative multidisciplinary team (surgeons, intensivists, microbiologists, nurses) and the primary care team [32]. Operative debridement is necessary to eliminate any tissue that appears necrotic and would otherwise remain an infectious nidus. The wound left following a deep SSI following operative debridement continues to be a clinical dilemma [33].

Cultures should be taken from any collected specimen, but broad spectrum antibiotics should be initiated immediately, especially when setting systemic signs of inflammation. Although increasingly less common; operational re-exploration is required if Interventional Radiology is unable to access the source [34].

### Prevention of surgical site infection

The optimal reduction of SSIs remains a challenge, despite several procedural advances. To date, most SSI preventive measures have focused unexplored on the surgical team with patient involvement intervention on SSI prevention so the effectiveness of this intervention remains to be assessed. In recent years the patient's active involvement in healthcare processes has gained momentum on a global scale as a means of improving patient safety [35,36]:

- Preoperative antibiotic administration has become a part of standard operating room protocols [37]. The use of antibiotics in suitable cases (usually water-contaminated, dirty or sterile cases where prosthetic material is implanted) makes sense intuitively and is simple and inexpensive, and many publications have documented its benefits [38].
- It is important to maintain postoperative blood glucose of 180 mg/dL or lower. Replace the advice to maintain postoperative blood glucose of less than 200 mg/dL at 6 am on postoperative days 1 and 2. In 2014, this measure will be revised in the SCIP to assess glucose control (180 mg/dL or less) in patients with cardiac surgery within a time frame of 18 - 24 hours after end-time anesthesia [39,40].
- Randomized controlled trials have shown the benefits of both preoperative and intraoperative warming to reduce SSI rates and to reduce intraoperative blood loss [41]. Even slight degrees of hypothermia can raise SSI rates. Hypothermia can directly impair

or indirectly impair the neutrophil function by triggering subcutaneous vasoconstriction and subsequent hypoxia to the tissue [42].

- Optimize the oxygenation of the tissue by providing supplemental oxygen during and immediately after mechanical ventilation operations [43].
- Using a World Health Organization (WHO) checklist to ensure that best practices are complied with to increase surgical patient safety. WHO checklist is a 19-item surgical safety checklist to increase adherence to best practices [44].
- As a risk factor for the development of SSIs, perioperative transfusion of leukocyte-containing allogeneic components was suggested, with leukocyte-reduced blood posing a much lower risk [45].
- Numerous randomized controlled trials have examined the practice of preoperative hair removal and its relationship to operational site infection [46]. Hair has often been perceived to be associated with lack of cleanliness and removal associated with prophylaxis infection. Different hair removal modalities include shaving, clipping and depilatory creams [47].

### Conclusion

There is a profound effect of SSIs on both patients and healthcare organizations; hence efforts should be focused on implementing complex multidisciplinary prevention strategies. We reviewed some essential preventive measures that can be quickly enforced to reduce the risk of SSI, as well as the cost of patient morbidity, mortality rate and health care. Knowledge of the important consequences of SSI for patient safety and treatment costs is of prime importance to any surgeon and tracking one's own activities in the operating room in relation to existing literature is an essential step in preventing infection and optimizing beneficial outcomes.

### Bibliography

1. Horan TC., *et al.* "CDC/NHSN surveillance definition of health care-associated infection and criteria for specific types of infections in the acute care setting". *American Journal of Infection Control* 36 (2008): 309-332.
2. Andersen BM. "Prevention of Postoperative Wound Infections". *Prevention and Control of Infections in Hospitals* (2018): 377-437.
3. Bengtsson S., *et al.* "Wound infections after surgery in a modern operating suite: clinical, bacteriological and epidemiological findings". *Journal of Hygiene* 83.1 (1979): 41-57.
4. Bayat A., *et al.* "Skin scarring". *British Medical Journal* 326 (2003): 88-92.
5. World Health Organization. WHO Surgical Safety Checklist Implementation Manual (First Edition). Spring (2008): 1-28.
6. Birkmeyer JD., *et al.* "Surgical skill and complication rates after bariatric surgery". *The New England Journal of Medicine* 369 (2013): 1434-1442.
7. Cruse PJ and Foord R. "The epidemiology of wound infections. A 10-year prospective study of 69,939 wounds". *Surgical Clinics of North America* 60 (1980): 27-40.
8. Wangenstein OH., *et al.* "Some highlights in the history of amputation reflecting lessons in wound healing". *Bulletin of the History of Medicine* 41 (1967): 97-131.
9. Garner BH and Anderson DJ. "Surgical Site Infections: An Update". *Infectious Disease Clinics of North America* 30.4 (2016): 909-929.

10. Engemann JJ, *et al.* "Adverse clinical and economic outcomes attributable to methicillin resistance among patients with *Staphylococcus aureus* surgical site infection". *Clinical Infectious Diseases* 36 (2003): 592-598.
11. Mangram AJ, *et al.* "Guideline for prevention of surgical site infection, 1999. Hospital Infection Control Practices Advisory Committee". *Infection Control and Hospital Epidemiology* 20 (1999): 250-278.
12. Allegranzi B, *et al.* "Report on the Burden of Endemic Health Care-Associated Infection Worldwide: A systematic review of the literature. Geneva: World Health Organization, WHO Document Production Services (2011).
13. Gastmeier P, *et al.* "Effectiveness of a nationwide nosocomial infection surveillance system for reducing nosocomial infections". *Journal of Hospital Infection* 64 (2006): 16-22.
14. Agency for Healthcare Research and Quality. Healthcare Cost and Utilization Project-statistics on hospital stays (2013).
15. Gaynes RP, *et al.* "Surgical site infection (SSI) rates in the United States, 1992-1998: the National Nosocomial Infections Surveillance System basic SSI risk index". *Clinical Infectious Diseases* 33.2 (2001): S69-S77.
16. Agência Nacional de Vigilância Sanitária (ANVISA) Critérios diagnósticos de infecção relacionada à Assistência à Saúde. Brasília (DF): Ministério da Saúde (2013).
17. Worth LJ, *et al.* "Diminishing surgical site infections in Australia: time trends in infection rates, pathogens and antimicrobial resistance overusing a comprehensive Victorian surveillance program, 2002-2013". *Infection Control and Hospital Epidemiology* 36 (2015): 409-416.
18. Astagneau P, *et al.* "Reducing surgical site infection incidence through a network: results from the French ISO RAISIN surveillance system". *Journal of Hospital Infection* 72 (2009): 127-134.
19. Rioux C, *et al.* "Impact of a six-year control program on surgical site infections in France: results of the INCISO surveillance". *Journal of Hospital Infection* 66 (2007): 217-223.
20. Delgado-Rodriguez M, *et al.* "Nosocomial infection, indices of intrinsic infections risk, and in-hospital mortality in general surgery". *Journal of Hospital Infection* 41 (1999): 203-211.
21. Cruse PJ and Foord R. "The epidemiology of wound infections. A 10-year prospective study of 69,939 wounds". *Surgical Clinics of North America* 60 (1980): 27-40.
22. Howard RJ and Lee JT. "Surgical wound infections: epidemiology, surveillance, and clinical management". In: Howard RJ, Simmons RL, editor. *Surgical Infectious Diseases*. 3. East Norwalk, CT: Allyn and Bacon (1995): 401-412.
23. Cruse P and Ford R. "The epidemiology of wound infection. 1. A 10-year prospective study of 62,939 wounds". *Surgical Clinics of North America* 60.1 (1980): 27-40.
24. Rioux C, *et al.* "Impact of a six-year control program on surgical site infections in France: results of the INCISO surveillance". *Journal of Hospital Infection* 66 (2007): 217-223.
25. Altemeier WA, *et al.* "Surgical considerations of endogenous infections- sources, types, and methods of control". *Surgical Clinics of North America* 48 (1968): 227-240.
26. Schaberg DR, *et al.* "Major trends in the microbial etiology of nosocomial infection". *The American Journal of Medicine* 91.3B (1991): 72S-75S.
27. Reichel M, *et al.* "Identification of variables for aerobic bacterial density that clinically relevant skin sites". *Journal of Hospital Infection* 78 (2011): 5-10.

28. Engemann JJ, *et al.* "Adverse clinical and economic outcomes attributable to methicillin resistance among patients with Staphylococcus aureus surgical site infection". *Clinical Infectious Diseases* 36 (2003): 592-598.
29. Klevens RM, *et al.* "Invasive, methicillin-resistant Staphylococcus aureus infections in the United States". *The Journal of the American Medical Association* 298 (2007): 1763-1772.
30. Anderson DJ, *et al.* "Clinical and financial outcomes due to methicillin-resistant Staphylococcus aureus surgical site infection: a multi-center matched outcome study". *PLoS One* 4 (2009): e8305.
31. Dumville JC, *et al.* "Negative pressure wound therapy for treating surgical wounds healing by secondary intention". *Cochrane Database of Systematic Reviews* 6 (2015): CD011278.
32. Vera RM. "Management of Surgical Site Infections". In: Moore L, Todd S. (eds) *Common Problems in Acute Care Surgery*. Springer, Cham (2017).
33. Astagneau P, *et al.* "Morbidity and mortality associated with surgical site infections: results from the 1997-1999 INCISO surveillance". *Journal of Hospital Infection* 48 (2001): 267-274.
34. Zarb P, *et al.* "National Contact Points for the ECDC pilot point prevalence survey, Hospital Contact Points for the ECDC pilot point prevalence survey. The European Centre for Disease Prevention and Control (ECDC) pilot point prevalence survey of health care associated infections and antimicrobial use". *Euro Surveillance* 17.46 (2012).
35. World Health Organization. *WHO Surgical Safety Checklist Implementation Manual (First Edition)*. Spring. (2008): 1-28.
36. Schweizer M, *et al.* "Effectiveness of a bundled intervention of decolonization and prophylaxis to decrease Gram positive surgical site infections after cardiac or orthopedic surgery: systematic review and meta-analysis". *British Medical Journal* 346 (2013): f2743.
37. Nichols RL and Holmes JW. "Prophylaxis in bowel surgery". *Current Clinical Topics in Infectious Diseases* 15 (1995): 76-96.
38. Page CP, *et al.* "Antimicrobial prophylaxis for surgical wounds: Guidelines for clinical care". *Archives of Surgery* 128 (1993): 79-88.
39. National Quality Forum (NQF) Cardiac Surgery Patients with Controlled Postoperative Blood Glucose. NQF; Washington, DC (2013).
40. Lazar HL, *et al.* "The Society of Thoracic Surgeons practice guideline series: blood glucose management during adult cardiac surgery". *The Annals of Thoracic Surgery* 87.2 (2009): 663-669.
41. Sessler DI. "Complications and treatment of mild hypothermia". *Anesthesiology* 95.2 (2001): 531-543.
42. Kurz A, *et al.* "Study of Wound Infection and Temperature Group Perioperative normothermia to reduce the incidence of surgical-wound infection and shorten hospitalization". *The New England Journal of Medicine* 334.19 (1996): 1209-1215.
43. Greif R, *et al.* "Outcomes Research Group Supplemental perioperative oxygen to reduce the incidence of surgical-wound infection". *The New England Journal of Medicine* 342.3 (2000): 161-167.
44. Haynes AB, *et al.* "A surgical safety checklist to reduce morbidity and mortality in a global population". *The New England Journal of Medicine* 360.5 (2009): 491-499.
45. Van de Watering LM, *et al.* "Beneficial effects of leukocyte depletion of transfused blood on postoperative complications in patients undergoing cardiac surgery: A randomized clinical trial". *Circulation* 97 (1998): 562-568.
46. Garner JS, *et al.* "Operating room practices for the control of infection in U.S. hospitals, October 1976 to July 1977". *Surgery, Gynecology and Obstetrics* 155 (1982): 873-880.
47. Cruse PJ and Foord R. "The epidemiology of wound infection: A 10-year prospective study of 62,939 wounds". *Surgical Clinics of North America* 60 (1980): 27-40.

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