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Surgical Site Infections: A Still Ongoing Challenge

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Abstract

Surgical site infections (SSI) have a high incidence, accounting for 20% of all hospital-acquired in-fections. Surgical site infections are linked to a increased length of stay and the risk of mortality. Although most patients recover from an SSI, 77% of mortality can be attributed to the infection it-self [1,4]. The incidence of SSI is 2% to 5% undergoing inpatient surgery [1]. Estimated annual in-cidence varies, but may range from 160,000 to 300,000 in the US [1,4]. These estimates might be understated, given the surveillance failure after discharge

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Introduction

Surgical site infections (SSI) have a high incidence, accounting for 20% of all hospital-acquired infections. Surgical site infections are linked to a increased length of stay and the risk of mortality. Although most patients recover from an SSI, 77% of mortality can be attributed to the infection itself [1,4]. The incidence of SSI is 2% to 5% undergoing inpatient surgery [1]. Estimated annual incidence varies, but may range from 160,000 to 300,000 in the US [1,4]. These estimates might be understated, given the surveillance failure after discharge.

The development of a SSI increases costs in the clinical and surgery outcomes. Certain patients may also require reoperation with SSI, which is associated with additional costs [5]. Broex et al. showed that in European hospitals patients who develop an SSI, the costs are double that of patients who do not [6]. In the same review, length of hospitalization was more than twice as long for patients with an SSI [6]. SSI may displace hospital resources that would be spent elsewhere, as well as delay patient´s operation.

SSI impacts on patient physical and mental health, morbidity and mortality. Moreover, patients may experience delayed wound healing and be more susceptible to other complications, such as sepsis [7,8]. Prolonged hospitalization and increased morbidity have been shown to negatively impact on patient health-related quality of life (HRQoL) [9].

Surgical Site Infections

Surgical site infections (SSIs) are defined as infections occurring up to 30 days after surgery, (or up to one year after surgery with implants) and may affect the incision and/or deep tissue at the operation site [10].

There are three different types of SSI defined by the Centers for Disease Control and Prevention (CDC): superficial infections, deep infections or involving organs or body spaces (Table 1) [11]. SSI in deep incisions or organ spaces account for 50% of all SSI [12]. The degree of contamination at the time of surgery influences the probability of SSI.

Before antibiotic prophylaxis the rates were about 1-2% for clean wounds, 6-9% for clean-contaminated wounds, 13-20% for contaminated wounds and 40% for dirty wounds [14], particularly with surgical procedures with high risk of infection (gastrointestinal) [15]. Yet, SSI remain a important cause of morbidity and death, maybe because of elderly surgical patients or chronic and immunocompromising diseases, prosthetic implants and organ transplantation [16]. We could observe little variation in the distribution of the pathogens isolated [17]. However, the change in the microbiology of SSI has increased involvement of microorganisms resistant to antibiotics.

Surgical procedures involving 'clean' cavities have less infection (3% to 5%), compared with procedures involving infected, necrotic or dirty tissues. Colorectal surgery, for example, might have surgical infection around 10% to 30% .

Definition of classification of surgical procedures is described as follows on table 2:

Methods

References for this review were identified through searches of PubMed, Cochrane Central Register of Controlled Trials (CENTRAL), EMBASE (Ovid)CINAHL, and World Health Organization (WHO), for articles published from January 1990 to March 2018 by use of the terms "surgical site infection," " surgical procedures " and "surgical infections". We also looked for clinical trials, meta-analysis and systematic reviews.

Results

There are a interventions consensus statements and guidelines that covers the pre-hospital setting and the post-discharge conditions. In the present study, we provide a brief of these guidelines.

Preoperative Bathing

Pre-operative bathing with chlorhexidine decreases skin pathogen concentrations, but do not reduce SSI [3].

Smoking Cessation

Smoking cessation 4 to 6 weeks before surgery reduces SSI and is recommended for all current smokers, especially those undergoing procedures with implanted materials. Most centers support the use of nicotine lozenges, nicotine gum, and medication to aid in smoking cessation [3,6].

Glucose Control

Blood glucose control should be done for all diabetic patients, but there is no evidence that decreases SSI risk [6].

Table 1. Surgical site infection classification.

Superficial Incisional
Purulent drainage from the superficial incision, with organisms isolated from culture.
Pain, swelling, redness, or heat
Presence of abscess
Infection of an episiotomy or newborn
Deep Incisional
Purulent drainage from the deep incision
A deep incision dehisces
An abscess or infection involving deep incision found on direct examination or during reoperation
Organ/Space
Purulent drainage from a drain that is placed through wound into the organ/spaceand organisms isolated from obtained from a culture
Abscess or infection involving the organ/space that is found on direct examination, reoperation, or radiologic examination.

Table 2. Infection according to wound classification.

Wound class	Definition	Example	Infection rate %
Clean	Non-traumatic, elective surgery, GI, respiratory and GU tract not entered	Mastectomy, vascular, hernias	2%
Clean-contaminated	Respiratory, GI,GU tract entered	Gastrectomy, hysterectomy	< 10%
Contaminated	Open, fresh, traumatic wounds, uncontrolled spillage, miner break in sterile Technique	Rupture app, emergent bowel resect	20%
Dirty	Open, traumatic, dirty wounds; traumatic perforation of hollow viscus, frank pus in the field	Intestinal fistula resection	28-70%

MRSA Screening Intervention

Clinical practice guidelines from the American Society of Health-System Pharmacists recommend screening decolonization for S aureus-colonized patients before joint replacement and cardiac procedures [20].

MRSA bundles (screening, decolonization, contact precautions, hand hygiene) are highly effective [22,23].

There is no standard decolonization protocol supported by literature, although should be completed close to date of surgery to be effective.

Bowel Preparation

Mechanical cleaning and antibiotic prophylaxis is recommended for elective colectomies.

Discussion

A significant number of SSIs occur following various surgical specialties in the world. Recent analysis of European studies confirmed that the financial burden of surgery is consistently higher in patients who develop an SSI, relative to uninfected patients. The mean total cost of orthopedic and trauma surgery in those who developed an SSI was about 2.9 times higher than the costs associated with patients who did not.

The literature generally supports the administration of prophylactic antibiotics within 1 hour before incision, or within 2 hours for vancomycin or fluoroquinolones, when indicated according to the type of operation. Administration before 120 minutes or after incision is associated with a higher risk of surgical site infection. The exact optimal timing within this timeframe cannot be defined according to the available evidence but half-life and protein- binding of the antibiotic should be taken in to account, also according to the underlying conditions of the individual patient. However, the evidence comes from studies with limited methodological quality and definitive randomized controlled trials are still needed. Prophylactic antibiotics should be redosed during surgery to maintain adequate tissue levels based on the agent's half- life or for every 1,500 mL estimated blood loss.

Providers should be aware of the common pathogens responsible for SSI (S aureus, coagulase ne-gative staphylococci, Enterococcus species, and Escherichia coli), as well as the patterns of resistance at their institutions [20]. Whenever possible, providers should use hospital- specific antibiograms and diverse antibiotic agents to decrease resistance among pathogens. As discussed previously, in elective colorectal procedures, a combination of oral antibiotic bowel preparation and IV prophylactic antibiotics should be used. Vancomycin should not be administered routinely as prophylaxis in MRSA- negative patients [21]. Antibiotics should be discontinued at time of incision closure (exceptions include implant-based breast reconstruction, joint arthroplasty, and cardiac procedures for which optimal duration of antibiotic therapy remains unknown). In general, there is no evidence that antibiotic administration after incision closure decreases SSI risk across a range of procedures, including clean, clean-contaminated, and contaminated wound classes [20,21]. Antibiotic prophylaxis after cardiothoracic procedures to continue until 48 hours postoperatively, however, many studies have shown no increased SSI risk with earlier antibiotic termination by 24 hours [20].

Future research should well describe and standardize aspects affecting the effect of timing. Also different pharmacokinetic properties should be taken in account. A protocol for a randomized control trial has been published earlier in 2015 [17].

Skin antiseptic preparation is aimed at reducing bacterial colonization of the skin and the risk of wound contamination during the surgical procedure. Iodophor [such as povidone-iodine (PI)] and chlorhexidine gluconate (CHG) are the main types of antiseptics and can be mixed with either alcohol or water. Chlorhexidine reduces skin bacterial colony counts to a greater extent than PI does or other agents that have been studied [18]. Adjunctive means to reduce contamination include measures to reduce airborne contamination in the operating room by use of tight scrub-suits and laminar airflow. The use of plastic adhesive drapes on the skin is commonly practiced but should be questioned, as it has in fact not been shown to reduce SSIs and might even increase the re- colonization of the skin [19].

Studies have shown that intra-operative hypothermia is associated with increased risk of SSI, therefore, intraoperative maintenance of normothermia is recommended. The use of preoperative warming before short, clean cases has been shown to reduce SSI and is recommended. For longer cases, both preoperative warming and ongoing temperature monitoring and warming measures are recommended [22].

Literature supports the use of wound protectors in reducing SSI, although data are mixed. Many prospective, randomized trials have demonstrated substantial reductions in SSI rate with the use of plastic wound edge protectors, although many of these studies are limited by small sample sizes.Some of these studies demonstrated considerable benefit in a more defined patient population, such as patients undergoing elective colorectal surgery [23]. The use of an impervious plastic wound protector can prevent SSI in open abdominal surgery, and evidence is strongest for elective colo- rectal and biliary tract procedures. The optimal postoperative wound management practices remain undefined, including how best to survey for SSIs after discharge from the hospital.

Traditional teaching has supported primary closure for clean and clean-contaminated cases, but delayed primary closure (DPC) or open wound management for contaminated and dirty wounds, given the increased risk of SSI. Recent research has questioned this dogma and explored whether primary closure can be acceptable for all wound classes [24]. Overall, there are no good quality data to support primary closure vs DPC in contaminated and dirty abdominal incisions, although systematic reviews suggest there might be decreased SSI with DPC. A prospective trial comparing primary closure with DPC reported that 48% of patients with primary closure were discharged with open wounds compared with 58% of patients with DPC (p 1/4 NS). In the setting of damage-control laparotomy, primary closure was associated with a higher rate of intra-abdominal infection, however, SSI did not develop in >85% of patients closed primarily [25]. Table 3 shows SSI at wound closure of an infected wound.

The aim of wound irrigation and lavage is to reduce the bacterial load in a surgical or traumatic wound by a combination of water pressure, dilution, or the application of antimicrobial agents. Usually, this is undertaken at the end of an operative procedure, prior to wound closure, to reduce the likelihood of the introduction of bacteria. Both wound irrigation and intra-cavity lavage can be achieved using various solutions. Normal saline is commonly used along with antimicrobial agents for intra-cavity lavage. However, there is concern that antimicrobial agents may damage tissue and prevent nor- mal healing. It is thought that the introduction of large volumes of fluid into a cavity or wound could wash away inflammatory cells vital to the host defence [26].

The use of topical and local antibiotic therapy options for SSI reduction has been explored in many surgical subspecialties, but there is a lack of high-quality data to support those therapies use to decrease SSI. It includes: antibiotic irrigations, topical antimicrobial agents, antimicrobial-impregnated dressings, and wound sealants [27]. There is some support in the literature for topical or local antibiotic use for specific procedures or patient populations. A recent systematic review found possible benefit for use in joint arthroplasty, cataract surgery, and possibly in breast augmentation and obese patients undergoing abdominal surgery [28]. There is

Table 3. Incidence of SSI of infected wounds

Opening and re-closure times	Re-infection rate %
Opening and re-closure at once	50
Opening and re-closure after 2 days	20
Opening and re-closure after 4 days	5
Opening and re-closure after 9 days	10

weak evidence in the literature to support routine use of topical or local antimicrobial agents, although there might be benefit for specific procedures and patient populations. The evidence base for intra-cavity lavage and wound irrigation is generally of low certainty. Therefore, might have possible difference in the incidence of SSI (in comparisons of antibacterial and non -antibacterial interventions, and pulsatile versus standard methods) these should be considered in the context of uncertainty, particularly given the possibility of publication bias for the comparison of antibacterial and non-antibacterial interventions. Clinicians should also consider whether the evidence is relevant to the surgical populations under consideration, the varying reporting of other prophylactic antibiotics, and concerns about antibiotic resistance.

Peri-operative oxygen administration is a simple, low cost SSI prevention strategy. A meta-analysis concluded that peri-operative supplemental oxygen led to a relative risk reduction of 25% [30,31]. Through a standardized protocol, provide guidance on the appropriate and timely use of supplemental oxygen through the surgical peri-operative period for all patients.

Conclusions

SSI prevention is multifaceted and attainable by following evilence-based strategies and recommended guidelines. This effort requires a mustidisciplinary approach that includes surgeons, anesthesiologists, leaders, preoperative staff, infection preventionists, pharmacists, engineering and environmental services.

Furthermore, SSIs negatively impact on patient outcomes, increasing patient morbidity, mortality, and HRQoL. As the demand for surgical procedures rises, the incidence and associated costs of SSIs will likely escalate.

Ongoing monitoring of compliance to bundles for data-driven decision- making, using data to drive practice and process changes, and communication of supporting process performance and SSI rates to physicians and peri-operative staff, and are also key to success.

References

1. Anderson DJ, Podgorny K, Berrios-Torres SI, et al. Strate- gies to prevent surgical site infections in acute care hospitals: 2014 update. Infect Control Hosp Epidemiol 2014; 35:605e627.
2. Bratzler DW, Dellinger EP, Olsen KM, et al. Clinical practice guidelines for antimicrobial prophylaxis in surgery. Am J Health Syst Pharm 2013;70:195e283.
3. Mangram AJ, Horan TC, Pearson ML, et al. Guideline for prevention of surgical site infection, 1999. Infect Control Hosp Epidemiol 1999;20:247e278.
4. Magill SS, Edwards JR, Bamberg W, et al. Multistate point- prevalence survey of health care-associated infections. N Engl J Med 2014;370:1198e1208.
5. O'Keeffe AB, Lawrence T, Bojanic S. Oxford craniotomy infections database: a cost analysis of craniotomy infection. Br J Neurosurg 2012;26:265e9.
6. Broex EC, Van Asselt AD, Bruggeman CA, Van Tiel FH. Surgical site infections: how high are the costs? J Hosp Infect 2009;72:193e201.
7. Gottrup F, Melling A, Hollander DA. An overview of surgical site infections: etiology, incidence and risk factors. EWMA J 2005;5:11e5.
8. Carnicer-Pont D, Bailey K, Mason B, Walker A, Evans M, Salmon R. Risk factors for hospital-acquired methicillin-resistant Staphylococcus aureus bacteraemia: a case control study. Epidemiol Infect 2006;134:1167e73.
9. Pinkney T, Calvert M, Bartlett D, Gheorghe A, Redman V, Dowswell G, et al. The impact of wound-edge protection devices on surgical site infection after laparotomy (ROSSINI trial): a multi- centre randomised controlled trial. Colorectal Dis 2013;15:18.
10. Owens CD, Stoessel K. Surgical site infections: epidemiology, microbiology and prevention. J Hosp Infect 2008;70:3-10.
11. Astagneau P, L'Hériteau F. Surveillance of surgical-site infections: impact on quality of care and reporting dilemmas. Curr Opin Infect Dis 2010;23:306-10.
12. SHEA, APIC, CDC, SIS. Consensus paper on the surveillance of surgical wound infections. Infect Control Hosp Epidemiol 1992;13:599-605.

13. Gottrup F, Melling A, Hollander DA. An overview of surgical site infections: etiology, incidence and risk factors. EWMA Journal 2005;5(2):11-5.

14. Humphreys H. Preventing surgical site infection. Where now? J Hosp Infect 2009;73:316-22.

15. 15. Hranjec T, Swenson BR, Sawyer RG. Surgical site infection prevention: how we do it. Surg Infect 2010;11:289-94.

16. Hranjec T, Swenson BR, Sawyer RG. Surgical site infection prevention: how we do it. Surg Infect 2010;11:289-94.

17. Mujagic E, Zwimpfer T, Marti WR, et al. Evaluating the optimal timing of surgical antimicrobial prophylaxis: study protocol for a randomized controlled trial. Trials 2014;15:188.

18. Veiga DF, Damasceno CAV, Veiga Filho J, Silva RV, Cordeiro DL, Vieira AM, et al. Influence of povidone-iodine preoperative showers on skin colonization in elective plastic surgery procedures. Plast Reconstr Surg 2008;121:115–8.

19. TegnellA,Are ´nC,OhmanL.Coagulase-negative staphylococci and sternal infections after cardiac operation. Ann Thorac Surg 2000;69:1104–9.

20. Anderson DJ, Podgorny K, Berrios-Torres SI, et al. Strategies to prevent surgical site infections in acute care hospitals: 2014 update. Infect Control Hosp Epidemiol 2014; 35:605e627.

21. Bratzler DW, Dellinger EP, Olsen KM, et al. Clinical prac- tice guidelines for antimicrobial prophylaxis in surgery. Am J Health Syst Pharm 2013;70:195e283.

22. Melling AC, Ali B, Scott EM, Leaper DJ. Effects of pre-operative warming on the incidence of wound infection after clean surgery: a randomized controlled trial. Lancet 2001; 358[9285]:876e880.

23. Mihaljevic AL, Schirren R, Ozer M, et al. Multicenter double-blinded randomized controlled trial of standard abdominal wound edge protection with surgical dressings versus coverage with a sterile circular polyethylene drape for prevention of surgical site infections: a CHIR-Net trial (BaFO; NCT01181206). Ann Surg 2014;260:730e737; discussion 737e739.

24. Cohn SM, Giannotti G, Ong AW, et al. Prospective randomized trial of two wound management strategies for dirty abdominal wounds. Ann Surg 2001;233:409e413.

25. Bhangu A, Singh P, Lundy J, Bowley DM. Systemic review and meta-analysis of randomized clinical trials comparing primary vs delayed primary skin closure in contaminated and dirty abdominal incisions. JAMA Surg 2013;148: 779e786.

26. Schultz GS,Davidson JM, Kirsner RS, Bornstein P, Herman IM. Dynamic reciprocity in the wound microenvironment. *Wound Repair and Regeneration* 2011;**19**(2):134–48.

27. O'Neal PB, Itani KM. Antimicrobial formulation and delivery in the prevention of surgical site infection. Surg Infect (Larchmt) 2016;17:275e285.

28. McHugh SM, Collins CJ, Corrigan MA, et al. The role of topical antibiotics used as prophylaxis in surgical site infection prevention. J Antimicrob Chemother 2011;66: 693e701.

29. Anderson, D.J. et al. (2014). Strategies to Prevent Surgical Site Infections in Acute Care Hospitals: 2014 Update.

30. Anderson, D.J. et al. (2014). Strategies to Prevent Surgical Site Infections in Acute Care Hospitals: 2014 Update. Infection Control and Hospital Epidemiology, 35(6), 605-627.

31. Qadan M, Akca O, Mahid SS, Hornung CA, Polk HC Jr. (2009). Peri-operative supplemental

32. oxygen therapy and surgical site infection: a met-analysis of randomized controlled trials. Arch Surg, 144(4):359-366