ISSN No:-2456-2165

An Overview of Surgical Site Infection and its Risk Factors, Pathogens, Treatment and Prevention

P. Nithyakala[1], Jessly Lalu[2], Karthiga.R.[3], Karthika. J.[4]
Department of Pharmacy Practice, Swamy Vivekanandha College of Pharmacy, Namakkal, Tamil Nadu, India

Abstract:- Infections known as SSIs are those that appear within thirty days of incision (or after a year if an implant is retained in place after the procedure.) and harm besides the wound at the surgery site or its surrounding in-depth tissue. SSI was divided into three groups. They are Skin-deep incisional, deep incisional, and organs/spaces. Although surgical site infection has been found to impact 50% or more of those in critical care facilities (ICUs) & between five to fifteen percent of those hospitalized are on common wards in wealthier countries, the severity of the issue is still frequently overestimated in underdeveloped nations. Surgical Site Infection risk remains after discharge. After being discharged from the hospital, about 2% of patients experience SSIs; these patients are at a two- to five-times greater risk of being readmitted. Micrococcus aureus, Coagulase-negative staphylococci, Streptococcus, Gram(-ve) bacilli, Streptococcus pneumoniae, anaerobic bacteria, Oropharyngeal Anaerobes, Enterococci, and Group B streptococci are some of the etiological causes of SSI. Preoperatively, intraoperatively, and postoperatively are the three stages that can be used to implement preventive measures. Although many studies base their outcome measures for SSI on accepted criteria, like those provided by the Surgical Site Infection Surveillance Service (SSIS) or the Centers for Disease Control and Prevention. Treatment for surgical site infection includes full wound debridement, wound drainage, and ongoing antibiotic therapy.

Keywords:- *Etiology, danger symptoms, Prevention, Treatment.*

I. INTRODUCTION

Hospital inpatients regularly experience health problems and death from infections at the surgery site. A large portion of nosocomial infections are brought on by hospital inpatients. [1]

In 1992, the phrase "surgical site infection" was released to take the role of earlier phrase "surgical wound infection." Surgical Site Infection are described as infections which harm the surgery site's incisions or deep tissue 30 days or less (or after a year if an implant is left in place following the procedure). Although operating room procedures have gotten better equipment sterilization techniques, better surgical techniques, and infection control strategies, this is true apartments, as these infections could affect organs or bodily parts and be superficial or deep incisional infections or both.[2]

Addressing infections at the surgical site, the most of which are caused by bacteria with multidrug resistance, is one of the biggest issues that surgeons today are dealing with Even in facilities that are modern, have approved preoperative preparation, and have antibiotic prophylactic policy, infections acquired in hospitals are still mostly caused by surgical sites, and rates are rising globally. This is accurate even when operating room protocols, surgical technique, tool sterilization methods, and infection prevention methods have all improved. [3]

In wealthy countries, it has been determined that SSI affects anywhere from 5 to 15 percent of those admitted on ordinary wards and up to 50% or more of patients in intensive care units (ICUs), although the severity of the problem is still routinely underappreciated in developing countries. [4]

15.9% postoperative incidence density was found in research conducted in MRRH in 2007 in order to determine the SSI incidence among elective procedures in the surgical ward, and there were no risk factors for SSIs present. Patients who encounter SSI require a great deal more medical care.

An SSI increases the likelihood that a patient will spend time in the ICU following surgery by 60% compared to uninfected surgical patients, as well as adding a median of two weeks to the hospital stay.

After discharge, SSI risk persists. Nearly 2% of patients get SSIs following hospital release, and these patients have a two- to five-times higher risk of being readmitted. [4]

A sizable majority of the populace has undergone one type of surgery or another at some point during their lifetime. With an estimated 234 million operations conducted each year, surgery has become a crucial component of worldwide health care.[5] When an SSI develops, the clinical and financial costs of surgery are greatly enhanced. Surgery costs are increased by the explicit prices associated with the individual's protracted hospital stay, examinations, and treatment. Additionally, some patients may require reoperation after contracting an SSI, which entails significant additional costs.[6]

II. SURIGICAL SITE INFECTION

Most prevalent well-known hospital-acquired infections and one of most challenging conditions for treatment is Surgical Site Infection.[7] Surgery area Specifically, infections are a type of healthcare-related illness that appear in the body part where surgery has been done. [8] An enormous disease burden, surgical site infections (SSIs) cause tremendous loss of scarce resources and people. [9]

ISSN No:-2456-2165

The amount of time of the individual's hospital stays, enhanced medical expenses, and patient mortality are all actual dangers.[10] Surgical-site infections (SSIs) cause at least 486,000 nosocomial infections annually, aggravating 2.7% of these infections, corresponding to the Centers for Disease Control and Prevention.[11] It is third most prevalently reported nosocomial infection, having negative effects on both the patient and the institution.[12]

Infections following surgery are significant participants in unfavorable resection outcomes in people, including increased morbidity, psychological anguish, additional costs, and delays in postoperative adjuvant therapy.[13] Infections at the surgical site are a serious danger for patients receiving lower extremity bypass.[14]

III. CLASSIFICATION OF SSI

In accordance with the System for tracking nosocomial infections (CDC NNIS). Three groups comprise the SSI classification system:-

- Skin-deep incisional
- Deep-incisional Infection
- Organs/spaces [15]

A. Skin-deep incisional Infection

Following surgery, a superficial infection appears 30 days subsequently. just the tissues beneath the skin and the skin and in some way relates to one of the following: [16]

A deep incision that is dripping with pus [16]

Microorganisms are extracted from the superficial incision's fluid or tissues for an aseptically acquired culture. [19]

The surgeon opens an instantaneous incision on purpose if one of the following indications of infection is present.: Until the wound is culture-negative, there should be an aching or discomfort, regional edema, and reddishness or warmth. [19]

The surgeon or attending doctor identifies superficial incision as surgery site infection.[19]

B. Deep Incision Infection

If an implant was inserted, an infection would show signs of being connected to the procedure and spread to the extensive soft tissues of the 30-day surgical procedure, or if the insert remained in place for a year.[19]

A deep incision with an organism found deep incisional soft tissues and at least one of the following symptoms: a deep wound that dehisces on its own/intentionally open or inhaled by the physician. more than 38°F fever, localized discomfort or soreness.

Drainage of pus from the deep incision.

On a physical anatomy, histology, or imaging examination, a blister/ further signs of infection close to an extensive cut are discovered. [17]

C. Organs/spaces deep to the incision

Whichever body part that was expanded or handled throughout the procedure, but not the incision, appears to be connected to the operation and is infected a month after the operation if there isn't an insert, or a year from today, when one appears. [19]

Purulent discharge from an organ or space-injured drain.

Organism(s) were found from the organ's liquid or tissue by culturally relevant testing or microbiological analysis without the use of culturing technique utilized for clinical evaluation or therapy. An abscess or other infection-related evidence discovered during a gross anatomical examination, histopathologic examination, or imaging test that is either conclusive or ambiguous proof of infection.[18]

IV. ETIOLOGY

- Staphylococcus;
- Mycobacterium coagulase-negative;
- Streptococci;
- Gram-negative microbe
- Streptococcus pneumoniae;
- Anaerobes;
- Oropharyngeal anaerobes;
- Enterococci;
- Group B streptococci [2]

V. RISK FACTORS & PATHOPHYSIOLOGY

To determine how much different risk variables connected to patients and procedures affect the likelihood of SSI, research has been done on these factors. There are two ways in which knowledge of the surgical method and patient traits that could affect the development of SSI is helpful:

- It allows for procedure stratification, expanding the scope of the surveillance data
- Prior to surgery, understanding risk factors may allow for more focused preventative actions.

Risk stratification also enables the identification of fluctuations in SSI rates that are not attributable to variations in immutable elements like the patient's vulnerability. [22]

Some of the risk factors that raise the possibility of SSI and its pathophysiology encompass the following:

ISSN No:-2456-2165

Table 1: Risk factors and pathophysiology

Risk Factor	Pathophysiology
Age	Abnormalities in the skin's fibroblast and underlying membranes, in addition to its provision of blood vessels and cutaneous nerves, that occur with age, might hinder wound healing.[23]
Diabetes	Innate protection against microorganisms is compromised by hyperglycemia. Additionally, a higher glucose level causes the glycosylation of proteins, which inhibits the healing of wounds. [24]
Malnutrition	Poor nutrition impairs the ability of tissues to recover, reduces the production of collagen, and causes granulomas to form in surgical wounds. [25]
Consuming Tobacco	Use of cigarette inhibits the healing of wounds by restricting blood arteries, inducing modifications in collagen metabolism, decreased inflammation, and relative ischemia. [26]
Obesity	Diminished circulatory rate to the lipid layer reduces delivery of oxygenating gas and antibiotics. [27]
Use of immunosuppressive drugs and diseases	The inflammatory stage of wound healing is decreased by anti-inflammatory medications / medical conditions. [28]
Reduced tissue oxygenation	A lack of oxygen may reduce the effectiveness of perioperative antibiotics. [29]
Thermoregulation during surgery	Thermoregulation during surgery lowers the body's defenses against surgical wound infection by vasoconstriction, which restricts immune cells' access to wounded tissue and slows the growth of scars. [30]
Postoperative hyperglycemia	By improving glycemic control and neutrophil binding, movement, digestion, and bactericidal activity, insulin may directly link decreased cellular function to high plasma glucose levels. [31]
Decoagulant	Decoagulants may result in chronic incisional leaking and sluggish wound healing. [32]
Blood transfusion	Blood transfusions alter the immune system, which influences the risk of infection. [33]
History of prior SSTI	There may be variations in innate immunity and susceptibility to infection that are associated to a prior history of SSTIs. [34]
Infection of wounds by personnel in the operation room	Lack of proper hand washing or gloving can cause skin bacteria on healthcare workers' hands to spread to patients and operating rooms where surgeries are being performed. [35]
Airborne contamination	The probability of SSI increases when more germs are present in the operating room environment. [36]
Duration of operation	Increased wound contamination, increased wound cell damage, and the local environment are all linked to longer operations. [37]
Surgical technique	Malpractice includes a wide range of actions, including as poor blood flow, rough manipulation of tissue, unexpected entry into the void viscus, leaving behind dead tissue, using too few drains and sutures, and failing to properly care for the area after surgery. [38]
Unidentified material	Unidentified objects encourage wounds at the spot of surgery and improve SSI risk. [39]
Injection of hormones inside a joint.	If strict antisepsis is not employed, following the injection process, an infection could spread, and may diminish the way the immune system reacts to the emergence of such germs in the host. [40]
Immunization into the joints	Immunization may spread during the compounding or infusion of these injections since catheters are routinely used to distribute the medications. A sterile hood is frequently not used when producing injections. [41]
Contamination of wound from patient	Shaving produces minor blisters that eventually serve as niduses for microbes to develop. [38]

ISSN No:-2456-2165

VI. MICROBIOLOGY OR PATHOGENS

The majority of SSIs are caused by pathogens that is a component of the own indigenous flora of the patient. [15] However, extrinsic sources of infection during surgery, such as microorganisms brought by medical personnel or heater-cooler infrastructure, might result in infections.[45] The germ that most frequently caused Surgery site infection was Staph aureus, and it was followed by Friedlander's bacillus, Schroeder, Bacillus coli, Iraqibacter, and Proteus mirabilis. The bacteria that cause infection at the surgical site vary depending on the location and sporadically even within a single place.[44] Conditions that are resistant to the antimicrobial methicillin The most common cause of infections affecting tissues with a soft exterior encountered in emergency rooms in the United States is the bacteria Staphylococcus aureus (MRSA). [43]

Nasal carriers of Staphylococcus aureus are more susceptible to this organism's healthcare-associated illnesses. More than 80% of S. aureus infections connected to healthcare are endogenous. [20]With regard to surgical technique and anatomical site, patient characteristics, and medical comorbidities, the microbiology of SSIs differs.[42]Gram-negative bacteria are very common in postoperative wound infections, and their acquisition is likely due to the patient's normal endogenous microbiome.[47]In various investigations, the preponderance of other creatures has fluctuated.[48]The organism's virulence is determined by its capacity to create poisons or other elements that enhance its capacity to infiltrate or harm tissue.[46]

Table 2: Types of Surgery and Microbiology

SURGERY TYPES	MICROBIOLOGY
Installation of any implants, grafts or prosthetic devices	Coagulase-negative staphylococci and Staphylococcus aureus [38][2][21]
Cardiac	S.aureus,coagulase-negative staphylococci[38][2][21]
Neurology	S.aureus,coagulase-negative staphylococci[38][2][21]
Breast	S.aureus,coagulase-negative staphylococci[38][2][21]
Ocular surgery	S. aureus; coagulase-negative staphylococci; streptococci; gram-negative bacilli[38][21][102]
Orthopedics	S. aureus; coagulase-negative staphylococci; gram-negative bacilli[38][2][21]
Noncardiac thoracic	S. aureus; coagulase-negative staphylococci; [38][2][21]
Vascular	S. aureus; coagulase-negative staphylococci; [38][2][21]
Appendectomy	Gram-negative bacilli; anaerobiotic [38][2][21]
Biliary tract	Gram-negative bacilli; anaerobiotic [38][2][21]
Colorectal	Gram-negative bacilli; anaerobiotic [38][2][21]
Gastroduodenal	Gram-negative bacilli; streptococci; oropharyngeal anaerobiotic (e.g., Pepto streptococci) [38][2][21]
Head and neck	Gram-negative bacilli; streptococci; oropharyngeal an aerobiotic s (e.g., Pepto streptococci) [38][2][21]
Obstetrics and Gynecology	Gram-negative bacilli; enterococci; group B [38][2][21]
Urology	Gram-negative bacilli [38][2][21]

VII. PREVENTION

To try and SSI risk in patients should be decreased having incision, numerous therapies is used. Generally speaking, there are three stages during which these treatments can be administered: preoperatively, intraoperatively, and postoperatively.[49]

A. PRE-OPERATIVE RECOMMENDATION:

- Preoperative showering [50]
- Preoperative antibiotic [51]
- Resistant organisms [51]
- Hair removal [50]
- Skin antisepsis [52]

➢ *Pre-operative Showering:*

Preoperative washing using Chlorhexidine gluconate formulations, is not firmly suggested to use 4% liquid or 2% coated cloth, largely because the clinical study was inadequately planned and carried out. Recent clinical research, however, demonstrates that a consistent regimen comprising both 4% liquid and 2% coated cloth formulations leads to high, repeatable, and long-lasting skin surface concentrations of CHG. [53]

A preoperative antiseptic shower or wash reduces the number of skin-infecting bacteria [54]

➢ *Preoperative Antibiotic:*

The anesthesia professionals typically administer prophylactic antibiotics during surgery. For the best chance of preventing surgical site infections, antibiotics must be given as soon as possible before the incision.[55]

The Surgical Care Improvement Programmed is an initiative jointly run by the Centers for Medicare and Medicaid Services and the Centers for Disease Control and Prevention, has established this measure's measurement and reporting as a significant quality endeavor since quick prophylactic antibiotic therapy is essential for better patient outcomes.[38]

The specific infection prevention strategies involve adjustments to antimicrobial prophylaxis that focus on timing, agent selection, and 24-hour cessation.[57]

➢ *Resistant organisms:*

Vancomycin is a prominent proactive antibiotic owing to the rising prevalence of Methicillin-resistant Staphylococcus aureus**.**[56]

Routine use of this antibiotic isn't advised unless there is an extremely high likelihood of Methicillin-resistant staph aureus infection, even though it may be the antibiotic of choice for individuals who have an allergy to cephalosporins.[58]

➢ *Hair removal:*

To mitigate the risk of infection at the operation site, never regularly shaving your hair. Prior to the procedure on that particular day, if hair needs to be cut, Vancomycin is a common antibiotic used as a prophylactic measure. Because they avoid using razors to shave as it will raise your risk of surgery site infection.[50]

In the past, shaving body hair from the anticipated surgical wound site was a standard component of getting patients ready for surgery. Removal of hair prior surgery, according to some research, is harmful to patients and should not be done since it may result in surgical site infections (SSIs).[62]

‘‘Both workers and patients should be properly attired and sterilized. Remove any jewelry and other valuables. Maintaining proper hygiene is important’’ [71]

B. INTRAOPERATIVE RECOMMENDATION:

➢ *Maintaining patient’s homeostasis [50}*
- Maintaining Normothermia [59]
- Increased Oxygen Delivery [59]
- Hyperglycemia [51]

➢ *Blood transfusion [51]*
➢ *Wound protectors [59]*
➢ *Wound irrigation [73]*
➢ *Closer method [51]*

C. MAINTAINING PATIENTS’ HOMEOSTASIS:

➢ *Maintaining Normothermia*

Devices for keeping patients warm before, during, and after surgery, as well as methods for determining the danger of hypothermia in patients.[60] Lower than 36.0°C patient core temperature is considered hypothermia. At any time during the perioperative pathway for adult surgical patients, hypothermia development is a possibility.[61]

➢ *Increased Oxygen Delivery*

More oxygen during surgery to mitigate the potential of surgical wound infection. Oxidative death, often known as destruction by oxidation, is the most beneficial barrier against surgical infections, this is influenced by the oxygen partial pressure in diseased tissue. To boost the oxygen tension in tissues with appropriate blood flow, one can easily increase the concentration of inspired oxygen.[63]

➢ *Blood transfusion*

Immunomodulation brought on by transfusion can result in reduced immunity as a result of blood transfusions and put patients at risk for SSIs [64]

Red blood cell transfusions are employed in the perioperative period to increase oxygen saturation in the blood, although they have been connected with difficulties, including as infection.[65]

In conjunction with an increase in the frequency of surgical site infections, transfusions are additionally contributing to a higher risk of nosocomial infections, mortality rates among patients in critical care, and other adverse outcomes. There is also a modest but persistent danger of transferring an infectious disease and a risk of allergic reaction associated with transfusion.[66]

➢ *Hyperglycemia*

To lessen postoperative complications, it is vital to adhere to perioperative glucose-lowering measures since prediabetes boosts the risk of surgical site infections (SSIs).[67]

It is suggested to practice strict glycemic control to avoid surgery site infections (SSI). Surgery patients' innate immune responses to infection can be greatly altered by acute hyperglycemia, leading to SSI.[68]

- WOUND PROTECTOR:

When performing a laparotomy, protect the borders of the abdominal wound from harm and infection, wound shields were developed. A projected decrease in the risk of SSI is a key factor in their development and use.[69]

Wound-edge protection devices (WEPDs), occasionally also referred to as "wound guards," have been implemented during abdominal surgery for a very long time. To mitigate the risk of surgical site infection, especially when operating on children, think about using sutures that have been coated with triclosan.

Consider using sutures rather than staples for securing the skin after a caesarean section to mitigate the risk of superficial lesion dehiscence. [70]

- WOUND IRRIGATION:

An open wound is irrigated intraoperatively by running a solution over its surface. It is a widely used procedure that is thought to aid in SSI prevention.[74]

- CLOSER METHOD

Preference should be given to non-woven, impermeable, disposable drapes. Although none of the existing recommendations specifically address it, the use of plastic film impervious to germs is meant to limit the migration of microorganisms after draping. [71].

‘Hand hygiene [72] and sterile gloves [50] should be properly maintained perioperative phase. The safety of intraperitoneal delivery of antibacterial medications during or after surgery as a preventative or treatment of infection was assessed in a systematic review encompassing 29 research studies and 50 observational studies. [73]

D. POSTOPERATIVE RECOMMENDATION:

For infected-looking wounds, surgeons frequently administer oral antibiotics in the postoperative setting to avoid the need for infection-related surgery. [75]

Surgeons typically prescribe oral antibiotics in the postoperative setting for wounds that seem infected in order to avert infection-related surgery.[76]

Discharge planning is to preserve the healing incision's integrity, inform patients about the symptoms of infection, and provide them with contact information in case of emergencies.[38]

VIII. TREATMENT

Consistent antibiotic therapy, wound drainage, and, if essential, complete wound debridement are all components of the treatment for SSI.[102] Closely observe all wounds, especially those that are in challenging places like skin folds and beneath them (such as the groin).[77]

IX. DISCUSSION

The additional most frequent root of nosocomial infections is infection at the surgical site.[81] Surveillance has helped to reduce the incidence of SSI by up to 38%, which also lowers the risk of hospital-acquired infections.[80] Due to obstetric and demographic factors, the infection rate after a caesarean section varies between 7% and 20%.[82] Healthcare-associated infections (HCAIs) diseases that arise no later than forty-eight hours after being admitted to the hospital and within 30 days of receiving medication. Or that occurred in a hospital or other healthcare facility.[83]Numerous patient- and facility-level factors can raise the risk of SSIs, but it's thought that by using emergent, evidence-based practices, about half of the SSIs may be prevented or reduced.[84]Surgical site infections are correlated with prolonged hospital stays and a two- to eleven-fold increase in mortality.[85] Up to 60% of SSIs are reportedly preventable, chiefly by complying to indicated evidence-based recommendations, such as prompt and proper antibiotic prophylactic dosing and preservation of perioperative normothermia.3,6 – 8.[87]

Surgical-site infections (SSIs), which contribute for at least 486,000 nosocomial infections yearly, complicate 2.7% of patients, According to CDC (Centers for Disease Control and Prevention) data.[88] Despite this change in how healthcare is provided, it appears that ambulatory surgical centers may not be paying enough attention to infection control, demonstrated by the increase in healthcare-associated infection (HAI) outbreaks and patient alerts brought on by weak prevention of infections in these and other outpatient settings. [90]

The World Health Organization (WHO) claims that there is a prevalence of SSI can vary between 5% and 34% worldwide. Long recovery durations from surgical infections may result in higher expenditures.[91] Recently, it was revealed that The Surgical Care Improvement Project, an acknowledged group of institutions who collaborate around the nation to improve the safety of surgical care, would get going.[92] Using the protocol for the surgical patient tracking component of the National Nosocomial Infections monitoring (NNIS) System, the efficiency of the NNIS basic risk score for predicting the chance of a surgical site infection was studied.[93] Due to the extended period of stay and elevated treatment costs, SSI is correlated with an enormous financial burden.[94] Surgical site infections (SSIs) that arise from surgery are increasingly used to gauge hospital quality.[95] Surgical site infections (SSIs) are estimated to occur in up to 15% of elective surgery patients and in about 30% of patients struggling contaminated or "dirty" surgery.[96] It was discovered that there were 24.6% of surgical sites were infected, of which 10% had deep sites, 9.2% had organ spaces, and 5.2% had superficial spaces.[97] The surveillance of healthcare facilities should be based on accepted definitions and practices and offer details on the epidemiology and microbiology of HAIs.[98] The most common post-major surgery gastrointestinal complication, surgical site infection (SSI), strikes 25% to 40% of patients completing midline laparotomies in high-income nations. SSI, which accounts for 8% of all invasive infection-related mortality and one-third of postoperative deaths.[99]

X. CONCLUSION

Although many studies base their use of the surgical site infection outcome measure on validated standards such those provided by the Centers for Disease Control and Prevention (CDC) or the Surgical Site Infection Surveillance Service (SSIS),[78] The significance of SSI prevention and control has been well acknowledged., and a variety of interventions, including surveillance systems, preoperative patient preparation, Prior to beginning surgery, the right antibiotics should be administered as a preventative measure. Aseptic procedures should also be followed in the operating room, and have been shown to be effective. [79] 2%–5% of patients receiving inpatient surgery experience SSIs.[86]

Healthcare-associated infections (HAIs), which trigger significant illness, death, extended hospitalizations and high overall healthcare costs, are a large subset of surgical-site infections (SSIs).[89] SSI is quite common among post-operative patients, particularly in underdeveloped nations.[100] SSI prevention and treatment strategies will become more crucial as the population ages and surgical treatments for the elderly are predicted to rise.[101]

Sometimes surgical site infection is life-threatening so surveillance should be maintained and it will decrease the surgical site infection.

REFERENCES

[1.] Setty NK, Nagaraja MS, Nagappa DH, Giriyaiah CS, Gowda NR, Naik RD. A study on Surgical Site Infections (SSI) and associated factors in a government tertiary care teaching hospital in Mysore, Karnataka. International Journal of Medicine and Public Health. 2014;4(2).

[2.] Owens CD, Stoessel K. Surgical site infections: epidemiology, microbiology, and prevention. Journal of hospital infection. 2008 Nov 1;70:3-10.

[3.] Sharan H, Misra AP, Mishra R. Determinants of surgical site infection in rural Kanpur, India. J Evol Med Dent Sci. 2012;1(6):921-8.
[4.] Lubega A, Joel B, Justina Lucy N. Incidence and etiology of surgical site infections among emergency postoperative patients in Mbarara regional referral hospital, South Western Uganda. Surgery research and practice. 2017 Jan 12;2017.
[5.] Bhasin SK, Roy R, Agrawal S, Sharma R. An epidemiological study of major surgical procedures in an urban population of East Delhi. Indian Journal of Surgery. 2011 Apr;73:131
[6.] Badia JM, Casey AL, Petrosillo N, Hudson PM, Mitchell SA, Crosby C. Impact of surgical site infection on healthcare costs and patient outcomes: a systematic review in six European countries. Journal of Hospital Infection. 2017 May 1;96(1):1-5.
[7.] Hasibi F, Thomas A. A Study on Surgical Prophylaxis of Antibiotics in Tertiary Care Hospital, Bangalore, India. Archives of Pharmacy Practice. 2021;1:47.
[8.] Gómez-Romero FJ, Fernandez-Prada M, Navarro-Gracia JF. Prevention of surgical site infection: analysis and narrative review of clinical practice guidelines. Cirugía Española (English Edition). 2017 Nov 1;95(9):490-502.
[9.] Morgan E, Onuminya JE, Usifoh I, EdwardPoluyi EO, Poluyi AO. Management and prevention of surgical site infections in spine surgery in a resource-poor setting: The Irrua protocol. Indonesian Journal of Neurosurgery. 2022 Jun 18;5(2):62-70.
[10.] Suljagić V, Jevtic M, Djordjevic B, Jovelic A. Surgical site infections in a tertiary health care center: Prospective cohort study. Surg Today 2010; 40:763-71.
[11.] Kirkland KB, Briggs JP, Trivette SL, Wilkinson WE, Sexton DJ. The impact of surgical-site infections in the 1990s: attributable mortality, excess length of hospitalization, and extra costs. Infect Control Hosp Epidemiol 1999;20:725—730.
[12.] Anvikar AR, Deshmukh AB, Karyakarte RP, Damle AS, Patwardhan NS, Malik AK, et al. A one year prospective study of 3280 surgical wounds. Indian J Med Microbiol1999;17:129-32.
[13.] Xue DQ, Qian C, Yang L, Wang XF. Risk factors for surgical site infections after breast surgery: A systematic review and meta-analysis. Eur J SurgOncol2012;38:375-81
[14.] Giles KA, Hamdan AD, Pomposelli FB, Wyers MC, Siracuse JJ, Schermerhorn ML. Body mass index: Surgical site infections and mortality after lower extremity bypass from the National Surgical Quality Improvement Program 2005-2007. Ann VascSurg2010;24:48-56
[15.] MangramAJ,HoranTC,PearsonML,SilverLC,Jarvis WR; Hospital Infection Control PracticeAdvisory Committee. Guideline for prevention of surgical site infection, 1999. Infect Control Hosp Epidemiol 1999;20:247 278.
[16.] Anderson PA, Savage JW, Vaccaro AR, Radcliff K, Arnold PM, Lawrence BD, Shamji MF. Prevention of surgical site infection in spine surgery. Neurosurgery. 2017 Mar 1;80(3S):S114-23.
[17.] Seidelman J, Anderson DJ. Surgical site infections. Infectious Disease Clinics. 2021 Dec 1;35(4):901-29.
[18.] Surgical site infection event.national healthcare safety network.2023;Pg.no:25
[19.] Eriksen HM. Surgical site infection at Kilimanjaro Christian Medical Center, Tanzania (Master's thesis).
[20.] Bode LGM, Kluytmans JAW, Heiman FL, et al. Preventing surgical siteinfections in nasal carriers of Staphylococcus aureus. N Engl J Med 2010;362:9–17
[21.] Bhasin SK, Roy R, Agrawal S, Sharma R. An epidemiological study of major surgical procedures in an urban population of East Delhi. Indian Journal of Surgery. 2011 Apr;73:131-5.
[22.] Eriksen HM. Surgical site infection at Kilimanjaro Christian Medical Center, Tanzania (Master's thesis).
[23.] Kaye KS, Anderson DJ, Sloane R, Chen LF, Choi Y, Link K, Sexton DJ, Schmader KE. The effect of surgical site infection on older operative patients. Journal of the American Geriatrics Society. 2009 Jan;57(1):46-54.
[24.] Zhang Y, Zheng QJ, Wang S, Zeng SX, Zhang YP, Bai XJ, Hou TY. Diabetes mellitus is associated with increased risk of surgical site infections: a meta-analysis of prospective cohort studies. American journal of infection control. 2015 Aug 1;43(8):810-5.
[25.] Hennessey DB, Burke JP, Ni-Dhonochu T, Shields C, Winter DC, Mealy K. Preoperative hypoalbuminemia is an independent risk factor for the development of surgical site infection following gastrointestinal surgery: a multi-institutional study. Annals of surgery. 2010 Aug 1;252(2):325-9.
[26.] Wukich DK, McMillen RL, Lowery NJ, et al. Surgical site infections after foot and ankle surgery: a comparison of patients with and without diabetes. Diabetes Care 2011;34(10):2211–3.
[27.] Meijs AP, Koek MBG, Vos MC, et al. The effect of body mass index on the risk of surgical site infection. Infect Control Hosp Epidemiol 2019;40(9):991–6.
[28.] Filsoufi F, Rahmanian PB, Castillo JG, et al. Incidence, treatment strategies and outcome of deep sternal wound infection after orthotopic heart transplantation. J Heart Lung Transpl 2007;26(11):1084–90.
[29.] Wetterslev J, Meyhoff CS, Jørgensen LN, Gluud C, Lindschou J, Rasmussen LS. The effects of high perioperative inspiratory oxygen fraction for adult surgical patients. Cochrane database of systematic reviews. 2015(6).
[30.] Kurz A, Sessler DI, Lenhardt R. Perioperative normothermia to reduce the incidence of surgical-wound infection and shorten hospitalization. Study

of Wound Infection and Temperature Group. N Engl J Med 1996;334(19):1209–15.
[31.] Latham R, Lancaster AD, Covington JF, et al. The association of diabetes and glucose control with surgical-site infections among cardiothoracic surgery patients. Infect Control Hosp Epidemiol 2001;22(10):607–12.
[32.] Wang Z, Anderson Jr FA, Ward M, Bhattacharyya T. Surgical site infections and other postoperative complications following prophylactic anticoagulation in total joint arthroplasty. PLoS One. 2014 Apr 9;9(4): e91755.
[33.] Rohde JM, Dimcheff DE, Blumberg N, Saint S, Langa KM, Kuhn L, Hickner A, Rogers MA. Health care–associated infection after red blood cell transfusion: a systematic review and meta-analysis. Jama. 2014 Apr 2;311(13):1317-26.
[34.] Faraday N, Rock P, Lin EE, et al. Past history of skin infection and risk of surgical site infection after elective surgery. Ann Surg 2013;257(1):150–4.
[35.] Leaper DJ, Edmiston CE. World Health Organization: global guidelines for the prevention of surgical site infection. Journal of Hospital Infection. 2017 Feb 1;95(2):135-6.
[36.] Lidwell OM, Lowbury EJ, Whyte W, et al. Airborne contamination of wounds in joint replacement operations: the relationship to sepsis rates. J Hosp Infect 1983;4(2):111–31.
[37.] Korol E, Johnston K, Waser N, et al. A systematic review of risk factors associated with surgical site infections among surgical patients. PLoS One 2013;8(12): e83743.
[38.] Mangram AJ, Horan TC, Pearson ML, et al. Guideline for prevention of surgical site infection, 1999. Infect Control Hosp Epidemiol 1999;20(4):247–80.
[39.] Elek SD, Conen PE. The virulence of Staphylococcus pyogenes for man; a study of the problems of wound infection. Br J Exp Pathol 1957;38(6):573–86.
[40.] Berríos-Torres SI, Umscheid CA, Bratzler DW, Leas B, Stone EC, Kelz RR, Reinke CE, Morgan S, Solomkin JS, Mazuski JE, Dellinger EP. Centers for disease control and prevention guideline for the prevention of surgical site infection, 2017. JAMA surgery. 2017 Aug 1;152(8):784-91.
[41.] Seidelman J, Baker AW, Anderson DJ, et al. Do periarticular joint infections present an increase in infection risk? Infect Control Hosp Epidemiol 2018;39(7): 890–1.
[42.] Warner SJ, Uppstrom TJ, Miller AO, O'Brien ST, Salvatore CM, Widmann RF, et al. The epidemiology of deep surgical site infections after pediatric spinal fusion surgery. Spine 2016;doi:10.1097/BRS.0000000000001735.
[43.] Moran GJ, Krishnadasan A, Gorwitz RJ, et al. Methicillin-resistant S. aureus infections among patients in the emergency department. N Engl J Med 2006;355:666–74.
[44.] Sharan H, Misra AP, Mishra R. Determinants of surgical site infection in rural Kanpur, India. J Evol Med Dent Sci. 2012;1(6):921-8.
[45.] SeidelmanJL, GeM,BakerAW,etal.Colon surgical–site infections and the impact of"present at the time of surgery(PATOS)" in a large network of community hospitals.Infect Control Hosp Epidemiol.PublishedonlineSeptember222022
[46.] Whitehouse JD, Friedman ND, Kirkland KB, Richardson WJ, Sexton DJ. The impact of surgical-site infections following orthopedic surgery at a community hospital and a university hospital: adverse quality of life, excess length of stay, and extra cost. Infect Control Hosp Epidemiol 2002;23(4):183 189
[47.] Malik S, Gupta A, Singh KP, Agarwal J, Singh M. Antibiogram of Aerobic Bacterial Isolates from Post-operative Wound Infections at a Tertiary Care Hospital in India. J Infect Dis Antimicrob Agents 2011;28:45-52
[48.] Isibor JO, Oseni A, Eyaufe A, Ahmadu T. Incidence of aerobic bacteria and Candida albicans in postoperative wound infections. Afr J Microbiol Res2008;2:288-91
[49.] 17Liu Z, Dumville JC, Norman G, Westby MJ, Blazeby J, McFarlane E, Welton NJ, O'Connor L, Cawthorne J, George RP, Crosbie EJ. Intraoperative interventions for preventing surgical site infection: an overview of Cochrane Reviews. Cochrane Database of Systematic Reviews. 2018(2).
[50.] National Institute for Health and Care Excellence. Surgical site infections: prevention and treatment. NICE guideline [NG125]
[51.] Hranjec T, Swenson BR, Sawyer RG. Surgical site infection prevention: how we do it. Surgical infections. 2010 Jun 1;11(3):289-94.
[52.] Anderson DJ, Sexton DJ, Cochran A, Collins KA. Overview of control measures for prevention of surgical site infection in adults. Massachusetts: UpToDate. 2017.
[53.] Global guidelines for the prevention of surgical site infection. World Health Organization 2016https://www.ncbi.nlm.nih.gov/pubmedhealth/PMH0095752/pdf/PubMedHealth_PMH0095752.pdf (Accessed on September 19, 2017).
[54.] Edmiston CE, Krepel C, Spencer M, et al. Evidence for preadmission showering regimen to achieve maximal antiseptic skin surface concentrations of chlorhexidine gluconate 4% in surgical patients. JAMA Surg 2015;150:1027-1032.
[55.] Nair BG, Newman SF, Peterson GN, Wu WY, Schwid HA. Feedback mechanisms include real-time electronic alerts to achieve near 100% timely prophylactic antibiotic administration in surgical cases. Anesth Analg 2010;111:1293–300.
[56.] Young B, Ng TM, Teng C, Ang B, Tai HY, Lye DC. Non-concordance with surgical site infection prevention guidelines and rates of surgical site infections for general surgical, neurological, and orthopedic procedures. Antimicrob Agents Chemother 2011;55:4659–63
[57.] Edmiston CE, Spencer M, Lewis BD, Brown KR, Rossi PJ, Henen CR, Smith HW, Seabrook GR.

Reducing the risk of surgical site infections: did we really think SCIP was going to lead us to the promised land? Surg Infect (Larchmt) 2011;12:1–9

[58.] Anderson DJ. Sexton DJ. Kanafani ZA, et al. Severe surgical site infection in community hospitals: Epidemiology, key procedures, and the changing prevalence of methicillin-resistant Staphylococcus aureus. Infect Control Hosp Epidemiol. 2007;28:1047–1053

[59.] Poggio JL. Perioperative strategies to prevent surgical-site infection. Clinics in colon and rectal surgery. 2013 Sep;26(03):168-73.

[60.] National Institute of Health and Clinical Excellence. Intraoperative hypothermia (Inadvertent). Clinical guideline 65. London: National Institute of Health and Clinical Excellence, 200.

[61.] for Nursing NC, UK SC. The Management of Inadvertent Perioperative Hypothermia in Adults [Internet].

[62.] Tanner J, Woodings D, Moncaster K. Preoperative hair removal to reduce surgical site infection. Cochrane Database Syst Rev 2006

[63.] Greif R, Akça O, Horn EP, Kurz A, Sessler DI; Outcomes Research Group. Supplemental perioperative oxygen to reduce the incidence of surgical wound infection. N Engl J Med 2000;342(3): 161–167

[64.] Higgins RM, Helm MC, Kindel TL, Gould JC. Perioperative blood transfusion increases risk of surgical site infection after bariatric surgery. Surgery for Obesity and Related Diseases. 2019 Apr 1;15(4):582-7.

[65.] Mazzeffi M, Tanaka K, Galvagno S. Red blood cell transfusion and surgical site infection after colon resection surgery: a cohort study. Anesth Analg 2017;125(4):1316-1321

[66.] Talbot TR, D'Agata EMC, Brinsko V, et al. Perioperative blood transfusion is predictive of poststernotomy surgical site infection: a marker for morbidity or true immunosuppressant? Clin Infect Dis 2004;38(10):1378-1382

[67.] Lai J, Li Q, He Y, Zou S, Bai X, Rastogi S. Glycemic Control Regimens in the Prevention of Surgical Site Infections: A Meta-Analysis of Randomized Clinical Trials. Frontiers in Surgery. 2022 Mar 25;9:855409.

[68.] Yoneda A, Takesue Y, Takahashi Y, Ichiki K, Tsuchida T, Ikeuchi H, Uchino M, Hatano E, Shinohara H, Tomita N. Improvement in hyperglycaemia prevent surgical site infection irrespective of insulin therapy in non-diabetic patients undergoing gastrointestinal surgery. World Journal of Surgery. 2020 May;44:1450-8.

[69.] Edwards JP, Ho AL, Tee MC, Dixon E, Ball CG. Wound protectors reduce surgical site infection: a meta-analysis of randomized controlled trials. Ann Surg 2012;256(1):53–59

[70.] Nichols RL, Choe EU, Weldon CB. Mechanical and antibacterial bowel preparation in colon and rectal surgery. Chemotherapy. 2005;51(Suppl. 1):115-21

[71.] Chauveaux D. Preventing surgical-site infections: measures other than antibiotics. Orthopaedics & Traumatology: Surgery & Research. 2015 Feb 1;101(1):S77-83.

[72.] Barbadoro P, Martini E, Savini S, Marigliano A, Ponzio E, Prospero E, D'Errico MM. In vivo comparative efficacy of three surgical hand preparation agents in reducing bacterial count. Journal of Hospital Infection. 2014 Jan 1;86(1):64-7.

[73.] De Simone B, Sartelli M, Coccolini F, Ball CG, Brambillasca P, Chiarugi M, Campanile FC, Nita G, Corbella D, Leppaniemi A, Boschini E. Intraoperative surgical site infection control and prevention: a position paper and future addendum to WSES intra-abdominal infections guidelines. World journal of emergency surgery. 2020 Dec;15(1):1-23.

[74.] De Simone B, Sartelli M, Coccolini F, Ball CG, Brambillasca P, Chiarugi M, Campanile FC, Nita G, Corbella D, Leppaniemi A, Boschini E. Intraoperative surgical site infection control and prevention: a position paper and future addendum to WSES intra-abdominal infections guidelines. World journal of emergency surgery. 2020 Dec;15(1):1-23.

[75.] Ghenbot Y, Wathen C, Gutierrez A, Spadola M, Cucchiara A, Petrov D. Effectiveness of Oral Antibiotic Therapy in Prevention of Postoperative Wound Infection Requiring Surgical Washout In Spine Surgery. World Neurosurgery. 2022 Jul 1;163:e275-82.

[76.] Monstrey SJ, Govaers K, Lejuste P, Lepelletier D, de Oliveira PR. Evaluation of the role of povidone-iodine in the prevention of surgical site infections. Surgery Open Science. 2023 Mar 16.

[77.] Sganga G, Baguneid M, Dohmen P, Giamarellos-Bourboulis EJ, Romanini E, Vozikis A, Eckmann C. Management of superficial and deep surgical site infection: an international multidisciplinary consensus. Updates in Surgery. 2021 Aug;73:1315-25.

[78.] Mallapur AS, Kalburgi EB, Shalavadi MH, Vibhavari W, Prakash K, Premkumar M, Chandrashekhar VM. Evaluation of rational use of antibiotics as surgical prophylaxis in a tertiary care teaching hospital. Medica Innovative. 2014;3(2):18-24.

[79.] Napolitano F, Izzo MT, Di Giuseppe G, Angelillo IF, Collaborative Working Group. Evaluation of the appropriate perioperative antibiotic prophylaxis in Italy. PloS one. 2013 Nov 13;8(11):e79532.

[80.] Ridgeway S, Wilson J, Charlet A, Kafatos G, Pearson A, Coello R. Infection of the surgical site after arthroplasty of the hip. J Bone Joint Surg 2005;87:844–50

[81.] Burke JP. Infection control – A problem for patient safety. N Engl J Med 2003;348:651-6.

[82.] Hafizoğlu RK, Kumbasar S, Şık BA, Bozkurt M, Ulaş M, Yumru AE, Dinçgez B, Salman S. Evaluation of the efficiency of antibiotic prophylaxis in cesarean cases. Proceedings in Obstetrics and Gynecology. 2016 Mar 1;6(1).

[83.] Haque M, Sartelli M, McKimm J, Bakar MA.

Healthcare-associated infections–an overview. Infection And Drug Resistance. 2018;11:2321.

[84.] Wahyuningsih IP. Analysis of the implementation of ido care bundles on the incidence of surgical site infections and their impact on patient length of stay. Journal of Health Science. 2020;24;1(6):366-76.

[85.] Ban KA, Minei JP, Laronga C, Harbrecht BG, Jensen EH, Fry DE, Itani KM, Dellinger PE, Ko CY, Duane TM. American College of Surgeons and Surgical Infection Society: surgical site infection guidelines, 2016 update. Journal of the American College of Surgeons. 2017 Jan 1;224(1):59-74.

[86.] Anderson DJ, Podgorny K, Berríos-Torres SI, Bratzler DW, Dellinger EP, Greene L, Nyquist AC, Saiman L, Yokoe DS, Maragakis LL, Kaye KS. Strategies to prevent surgical site infections in acute care hospitals: 2014 update. Infection Control & Hospital Epidemiology. 2014 Sep;35(S2):S66-88.

[87.] Meeks DW, Lally KP, Carrick MM, Lew DF, Thomas EJ, Doyle PD, Kao LS. Compliance with guidelines to prevent surgical site infections: As simple as 1-2-3?. The American Journal of Surgery. 2011 Jan 1;201(1):76-83.

[88.] Kirkland KB, Briggs JP, Trivette SL, Wilkinson WE, Sexton DJ. The impact of surgical-site infections in the 1990s: attributable mortality, excess length of hospitalization, and extra costs. Infect Control Hosp Epidemiol. 1999;20(11):725–730.

[89.] Ming DY, Chen LF, Miller BA, Anderson DJ. The impact of depth of infection and post discharge surveillance on rate of surgical-site infections in a network of community hospitals. Infect Control Hosp Epidemiol. 2012;33(3):276–282.

[90.] Schaefer MK, Jhung M, Dahl M, Schillie S, Simpson C, Llata E, Link-Gelles R, Sinkowitz-Cochran R, Patel P, Bolyard E, Sehulster L. Infection control assessment of ambulatory surgical centers. Jama. 2010 Jun 9;303(22):2273-9.

[91.] Lumbantobing R, Maulia SH, Novelyn S. Overview of Evaluation of Prophylactic Antibiotics in Patients with Hernia Cases at a Private Hospital in South Tangerang, Indonesia, during the Period January 2019–December 2020. Journal of Complementary and Alternative Medical Research. 2022;19(4):31-42.

[92.] Bratzler DW, Hunt DR. The surgical infection prevention and surgical care improvement projects: national initiatives to improve outcomes for patients having surgery. Clinical infectious diseases. 2006 Aug 1;43(3):322-30.

[93.] Gaynes RP, Culver DH, Horan TC, Edwards JR, Richards C, Tolson JS, National Nosocomial Infections Surveillance System. Surgical site infection (SSI) rates in the United States, 1992–1998: the National Nosocomial Infections Surveillance System basic SSI risk index. Clinical Infectious Diseases. 2001 Sep 1;33(Supplement_2):S69-77.

[94.] de Lissovoy G, Fraeman K, Hutchins V, Murphy D, Song D, Vaughn BB. Surgical site infection: incidence and impact on hospital utilization and treatment costs. Am J Infect Control 2009; 37(5):387–397.

[95.] Kao LS, Ghaferi AA, Ko CY, Dimick JB. Reliability of superficial surgical site infections as a hospital quality measure. J Am Coll Surg 2011;213(2):231–235

[96.] Petherick ES, Dalton JE, Moore PJ, Cullum N. Methods for identifying surgical wound infection after discharge from hospital: a systematic review. BMC Infect Dis 2006;6:170

[97.] Mezemir R, Seid A, Gishu T, Demas T, Gize A. Prevalence and root causes of surgical site infections at an academic trauma and burn center in Ethiopia: a cross-sectional study. Patient safety in surgery. 2020 Dec;14:1-7.

[98.] Kołpa M, Wałaszek M, Różańska A, Wolak Z, Wójkowska-Mach J. Epidemiology of Surgical Site Infections and Non-Surgical Infections in Neurosurgical Polish Patients—Substantial Changes in 2003–2017. International journal of environmental research and public health. 2019 Mar;16(6):911.

[99.] Collaborative G. Determining the worldwide epidemiology of surgical site infections after gastrointestinal resection surgery: protocol for a multicentre, international, prospective cohort study (GlobalSurg 2). BMJ open. 2017 Jul 1;7(7):e012150.

[100.] Salahuddin M, Muddebihal F, Thirunavukkarasu A, Alanazi AA, Alrashdi AM, Alrashidi AM, Alanazi WO, Alruwaili AH, Alruwaili AF, Alruwaili KN. Epidemiology and Risk Factors of Post Operative Site Infections in Surgical Patients: A Systematic Review. Archives of Pharmacy Practice. 2022 Jan 1;13(1).

[101.] Bagdasarian N, Schmader KE, Kaye KS. The epidemiology and clinical impact of surgical site infections in the older adult. Current translational geriatrics and experimental gerontology reports. 2013 Sep;2:159-66.

[102.] Alsharari AZ, Alruwaili WM, Saba HE, Alanazi NM, Alkhaldi AB, Alruwaili MM, Alhumud MB, Alfaleh LA, Bakri FF, Alsharari SN, Alhajouj AM. Diagnosis and Management of Surgical Site Infections: Narrative Review. Journal of Pharmaceutical Research International. 2021 Dec 11;33(54B):65-71.