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Review on surgical site infections

G.Ramya Balaprabha, SD Sandhya, K.Pragna, Ch.Madhav, Sushanth krDas, DR.K.Abbulu

Department of Pharm.D, CMR College of Pharmacy, Kandlakoya, Medchal, Telangana – 501401.

***Corresponding author: Dr. G. Ramya Balaprabha**

ABSTRACT

Surgical site infections (SSI) are the wound infections which occur within a time period of 30days in superficial incisional SSI and can extend to 1year after surgery in case of prosthetic implantation (deep incisional SSI) or can occur in traumatized organ/space like pleural space, peritoneal space, joint space etc. Surgical Site Infections can be classified into different categories depending upon the site and extent of infections. They are incisional SSI and organ SSI where incisional SSI is further subdivided into Superficial SSI and deep incisional SSI. Staphylococcus aureus and Coagulase negative staphylococci is the primary cause of infection in SSI. Wound swabbing and serum examinations are the used diagnostic technique for SSI diagnosis. National Nosocomial Infections Surveillan (NNIS) is the common tool to predict risk of SSI and other ways of assessing risk are ASEPSIS and Southamptom scoring system. With increasing risk of SSIs, wound can be classified into four different classes. They are clean, contaminated, clean-contaminated and dirty wounds. The Recommended antibiotic for surgical site infection is first generation cephalosporin's particularly Cefazolin.

Keywords: Surgical site infection, Asepsis, Prosthetic implantation

INTRODACTION

Surgical Site Infection (SSI) is most frequently occurring healthcare associated infection (HAI) which occurs within 30days of surgery at surgical site. [1, 2] High rate of SSI are responsible for increased mortality, morbidity, economic burden and post operative hospital stay. [2, 3] SSI is still a threat to surgical world inspite of great advancement in surgical and aseptic techniques in post listerian era. [3] According to Centers for Disease Control (CDC) definition for post operative infection, many studies have identified SSI during the hospitalization (pre-discharge) as well as post discharge. [4] Surgical site infections are the wound infections which occur within a time period of 30days in superficial incisional SSI and can extend to 1year after surgery in case of prosthesis implantation (deep incisional SSI) or can occur in traumatized organ/space like pleural space, peritoneal space, joint space etc. [5, 6]

Epidemiology

Surgical site infection was considered to be the most prevalent infection and most commonly in orthopedic wards according to the national study of nosocomial infections. [7] There is no gender differences and generally they are procedure specific but males are more prone to surgical site infections than females according to study conducted by Gamal A. Khairy. [8, 9] SSI's diagnosis rate falls between 12% to 84% and are

most often seen between 4 to 6 days after surgery. [10]

ETIOLOGY

According to literatures, less than 5% of all bacteria like staphylococcus, streptococcus, Escherichia and pseudomonas only can be easily grown on culture media and remaining 95% bacteria which cannot be grown and isolated may be one of the causative factors for SSI and can create limitations in targeting therapies to the microorganisms. [11]

Metabolic and endocrine disturbances are seen due to surgical stress and anesthesia leads to suppression of generalized immune. Surgical stress response is reduced due to use of neuraxial anesthesia by noxious afferent inputs blockage and this might be the reason of complication of infection. [12] Based on the surgical procedures, microorganism causing infections differs. Staphylococcus aureus is the primary cause of infection in clean surgical procedures and aerobic and anaerobic flora is the main cause of infection in clean contaminated, Contaminated and Dirty surgical procedures. [13] Methicillin-resistant S aureus (MRSA) is increasing rapidly and is seen in two-thirds of S aureus infections. [14]

Percentage of isolates which were collected from SSI based on the data collected by NNIS system (national nosocomial infections surveillance system) is as follows: [15]

Microorganisms	Percentage of isolates (1990-1996)
Staphylococcus Aureus	20
Coagulase negative staphylococci	14
Enterococcus spp.	12
Escherichia coli	8
Pseudomonas aeruginosa	8
Enterobacter spp.	7
Proteus mirabilis	3
Klebsiella Pneumoniae	3
Candida albicans	3
Group D Streptococci (non-enterococci)	2
Other gram-positive aerobes	2
Bacteroides fragilis	2

CLASSIFICATION OF SURGICAL SITE INFECTION

❖ **Surgical Site Infections classified into different groups depending on the site and extent of infections:**

➢ **Superficial incisional SSI** should meet the following criteria:

✓ Superficial incisional SSI is infection occurs after surgery within 30days and only skin or subcutaneous tissue of incision is involved.

✓ Superficial incisional SSI is considered if atleast any one of the following is seen in patient:

1. Purulent discharge from the superficial incision.
2. Identification of organism using discharge fluid or tissue from superficial incision.
3. If culture test is negative and if any one of the sign or symptoms like pain, redness, heat and swelling are present when wound opened by physician.
4. If Superficial SSI is diagnosed by surgeon or physician.

✓ Superficial incisional SSI is of two types: Primary and secondary.

➢ **Deep incisional SSI** should meet the following criteria:

- ✓ Deep incisional SSI is infection occurs after surgery within 30days and time period can extend upto 1year incase of any prosthetic implantation is placed and deep soft tissues of the incision is involved.
- ✓ Deep incisional SSI is considered if atleast any one of the following is seen in patient:

1. Purulent discharge from the deep incision.
2. If culture test is negative and if any one of the sign or symptoms like fever >38°C, localized pain or tenderness are present when wound is opened by physician.
3. Detection of any evidence of infection like abscess based on direct observation or by any radiological examination.
4. If deep incisional SSI is diagnosed by surgeon or physician.

- ✓ Deep incisional SSI is of two types: Primary and secondary.

- ➢ **Organ/space SSI** should meet the following criteria:
- ✓ Thos is a type of infection that includes any part of the body (organs/spaces).
- ✓ Infection is seen within 30 to 90 days after surgery.
- ✓ Organ/Space SSI is considered if atleast any one of the following is seen in patient:

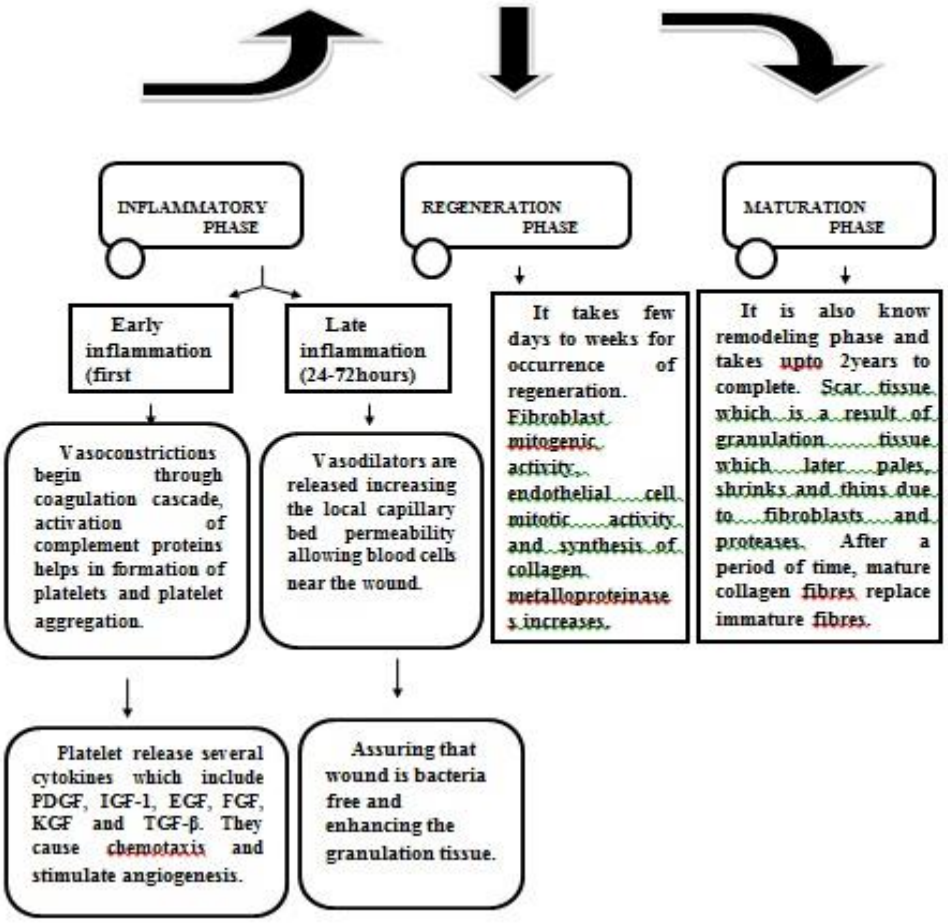
1. Purulent drainage from organ/space (Closed suction drainage system, open drain, T-tube drain).
2. Identification of organism from fluid in the organ/space.
3. Detection of any evidence of infection like abscess based on direct observation or by any radiological examination.
4. If organ/space SSI is diagnosed by surgeon or physician. [16, 17]

PATHOPHYSIOLOGY

SSI causing microorganisms can either be exogenous (from external environment) or endogenous (from patient's own flora) can easily be eliminated from surgical site because of innate host defense mechanism. When a person undergoes any surgery, skin and subcutaneous tissue is incised creating acute surgical wound which undergo reparative process restoring anatomic and functioning integrity. Acute wound can become chronic wound if it does not heal within 6weeks of incision. Generally surgical wound heals without PMNs. Monocytes enter the surgical site after 24hours of incision and when there is very low bacterial contamination neutrophils entering surgical site will control the bacteria. These monocytes will further produce chemical signals for wound healing. If this bacterial contamination is very high then these monocytes will play role of proinflammatory cells releasing potent cytokine like tissue necrotic factor (TNF-α), interleukins (IL-1, IL-6) producing potent signals regulating vigorous neutrophils activity. [18, 19]

Biofilms are the group of microorganism that seems to be adhered to an underlying tissue substratum. The colony can be degraded through physical disruption using brushes or other physical means. After disruption, colony tries to reconstitute but antibiotics, biocides, quorum-sensing inhibitors can be used for complete eradication. Removing any devitalized tissue frequently and later managing wound surface area physically or enzymatically to suppress the re-accumulation of biofilm. After suppression, host healing process become more effective like angiogenesis, extracellular matrix formation and wound contraction. [13]

Generally this healing process can be divided into three phases



DIAGNOSIS

It is very important to diagnose and know the causative organism to finalize which antibiotic suitable for infection. The most commonly used sampling technique is wound swabbing at the time of dressings or on weekly interval basis which is neither much helpful nor cost effective. The other investigations like serum examinations (elevated WBCs, CRP) and Quantative analysis (wound biopsy). [20]

Risk factor

Surgery patients are more prone to risk of SSI and these risks can be roughly divided into two categories, intrinsic and extrinsic factors. Information related to intrinsic risk factors is useful to employ special precautions to protect patients who are prone to infections. Calculation of risk specific rates permits comparison of rates amongst patients with similar risks in different hospitals.

INTRINSIC RISK FACTORS ASSOCIATED WITH SURGICAL SITE INFECTIONS	
Surgical site infection	*Severity of illness(e.g. High American Society for Anesthesiology Score, diabetes mellitus) *Obesity *Advanced age *Malnutrition

	*Trauma *Loss of skin integrity(e.g. Psoriasis) *Presence of distant infection

EXTRINSIC RISK FACTORS ASSOCIATED WITH SURGICAL SITE INFECTIONS	
Surgical Site infection	*Operative procedure performed *Degree of microbiological contamination of operative field *Duration of the operation *Usage of invasive devices *Environmental factors like water, air and food.

High risk medical interventions like surgical operations and usage of invasive devices, degree of microbiological contamination of the operative field, duration of operation are considered to be the major extrinsic risk factors. Continuous use of high risk device may increase the risk making it unpreventable. NNIS System has developed SSI risk index that acclimate SSI rates for most operation. [21] National Nosocomial Infections Surveillan (NNIS) is the common tool which is used to predict risk of surgical site infection and is basic risk index. There are two reasons for which SSI risk is very helpful: Determining the SSI risk helps in deciding whether is there a need to employ preventive strategies (such as prophylactic antibiotics), and SSI risk helps in comparing SSI rates between patient groups. Earlier CPT3 score was widely used which consists of two stages to predict risk of SSI. First stage included binomial logistic regression to identify the covariates separately associated with SSI and later used it to predict SSI risk. This statistics was called CPT3 score. In second stage CPT3 was added to other covariates and used it to identify all covariates associated with SSI separately. [22] Higher SSI risk is seen in patients who generally undergo colorectal surgery or obstetric gynecological procedures like cesarean delivery and oncologic resections. The hypothermia complication is common risk factor for patients who undergo surgery due to cutaneous vasoconstriction, hypoxia and immune cell function impairment. Therefore in post operative cases, maintenance of perfusion and control in hypoxic condition can reduce SSI. [23] There are four different classes of wound with increasing risk of SSIs which has been widely used to estimate the rate of infection after surgery. They are:

Clean

It is an uninfected operated wound which is primarily closed, if necessary drained with closed drainage. There is no inflammation and respiratory, alimentary, urinary tracts are not entered.

Clean contaminated

These are the surgical operative wounds which enter respiratory, alimentary, and genital or urinary tracts under controlled condition without unusual contamination and with no evidence of infection or unsterile techniques.

Contaminated

These are fresh open wounds in which acute non purulent inflammation is seen and necrotic tissue without evidence of purulent drainage. Surgeries without proper sterile techniques or gross spillage from GIT.

Dirty

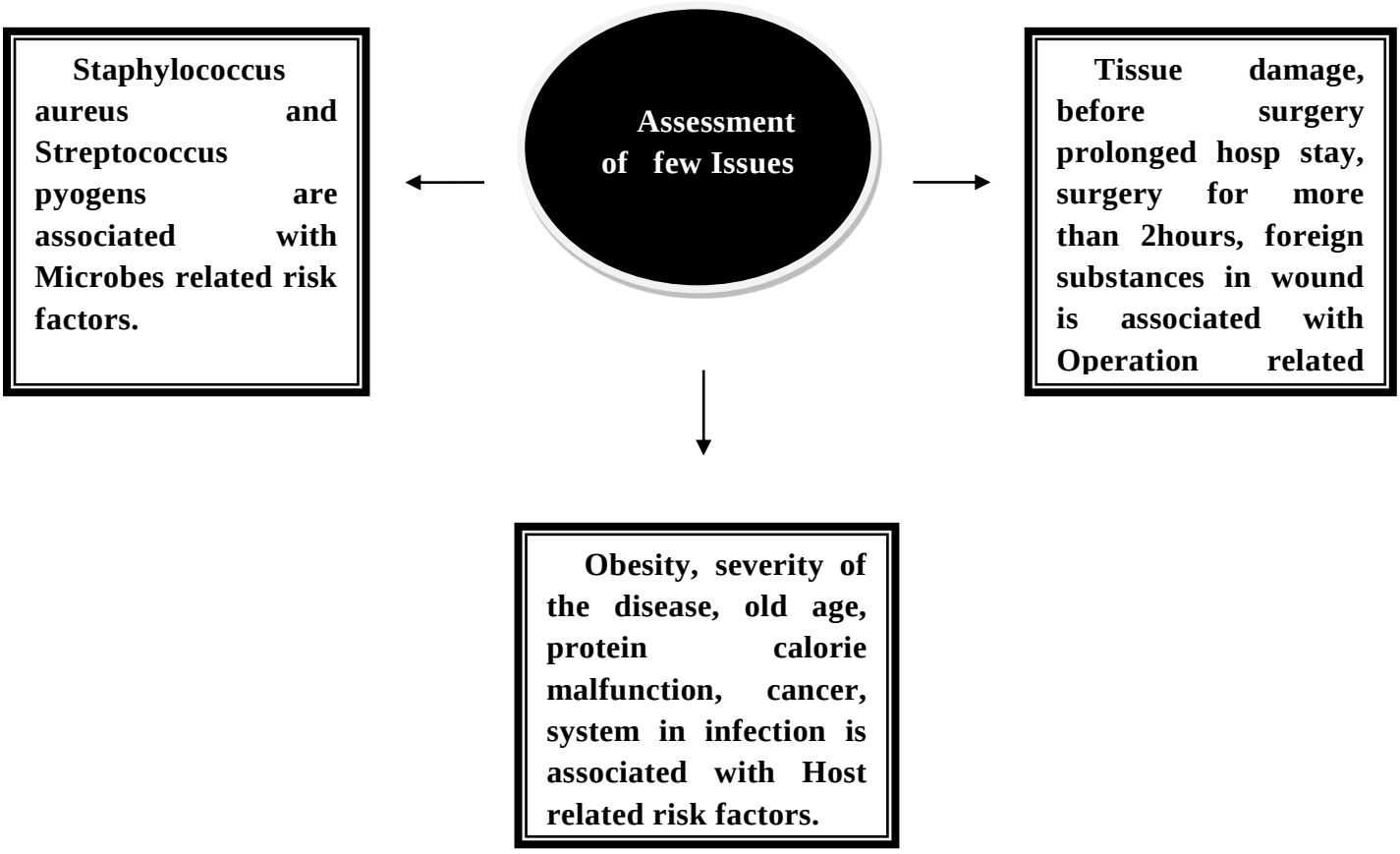
These includes old traumatic wound with necrotic tissue and involves existing clinical infection. In this case, organisms causing post operative infections are present in the operation room before surgery. [24]

Classification of wound for assessment of risk of SSIs [24]

CLASSIFICATION OF WOUNDS	CRITERIA	ANTIBIOTICS
CLEAN	Elective cases, non emergency, non traumatic, primarily closed; no acute inflammation; no break in techniques.	Indicated only in high risk procedure

CLEAN-CONTAMINATED	Emergency cases with clean procedure; elective opening of tracts with minimal spillage; minor technique break.	Prophylactic antibiotics are
CONTAMINATED	Non purulent and acute inflammation; major spillage/ break in technique; penetrating trauma <4hours old.	Prophylactic antibiotics are
DIRTY/INFECTED	Purulent inflammation (e.g. abscess); penetrating trauma >4hrs old.	Therapeutic antibiotic are indicated

Patient who undergo surgery can be divided into 4 different categories and can easily be assessed on the few issues after entering operating room. These issues are microbes related factors, Host related and operation related. [25]



There are many wound grading system for assessing the risk of infection. Most commonly used systems are ASEPSIS wound scoring system and Southampton wound scoring system. The main aim of devising ASEPSIS was to assess wounds due to cardiothoracic surgery, while the Southampton scale was devised to assess postoperative hernia wounds. [26]

Asepsis wound scoring system [26]

ASEPSIS WOUND SCORE	PROPORTION OF WOUND AFFECTED					
Wound Charactersitics	0	<20	20-39	40-59	60-79	>80
Serous exudates	0	1	2	3	4	5
Erythema	0	1	2	3	4	5
Purulent exudates	0	2	4	6	8	10
Separation of deep tissues	0	2	4	6	8	10

Points are scored for daily wound inspection

Criterion	Points
Additional treatment:	
Antibiotics	10
Drainage of pus under local anesthesia	5
Debridement of wound(general anesthesia)	10
Serous discharge*	Daily 0-5
Erythema*	Daily 0-5
Purulent Exudate*	Daily 0-10
Separatioin of deep tissues*	Daily 0-10
Isolation of bacteria	10
Stays as inpatient prolonged over 14 days	5

*Given Score only on five of seven days. Highest weekly score used.

Category of infection: total score 0-10 = Satisfactory healing;
11-20 = Disturbance of healing; 20-30 = Minor wound infection;
31-40 = Moderate wound infection; >40 = Severe wound infection.

Southampton scoring system [26]

GRADE	APPEARANCE
0	Normal healing

I Normal healing with mild bruising or erythema:

A	Some Bruising
B	Considerable bruising
C	Mild erythema

II Erythema plus other signs of inflammation:

A	At one point
B	Around Sutures
C	Along wound
D	Around wound

III Clear or haemoserous discharge

A	At one point only(<2cm)
B	Along wound(>2cm)
C	Large volume
D	Prolonged(>3days)

Major complication
IV Pus

A	At one point only(<2cm)
B	Along wound(>2cm)

V Deep or Severe wound infection with or without tissue breakdown; haematoma requiring aspiration.

The wound grading system used was simplified for the use of analysis.
By using the worst wound score recorded and information about any treatment instituted either in hospital or the community, wounds were regarded in four categories:
(A) Normal healing;
(B) Minor complication;
(C) Wound infection-wounds graded IV or V or wounds treated with antibiotics after discharge from hospital, irrespective of the wound grading given to them by the nurse; and
(D) Major haematoma- wound or scrotal haematomas requiring aspiration or evacuation.

Southampton is considered to be much more simpler and easier than ASEPSIS system which classify wound based on complications and their extent. Southampton scale can record score and information about treatment using worst wound. Based on this scoring system, wounds are divided into four:

a. Normal healing
b. Minor complication
c. Wound infection- Wounds are graded as IV or V and wounds treated with antibiotics after discharge.
d. Major Haematoma- Wound or scrotal haematomas requiring aspiration.
e. Haematoma- Wound or scrotal haematomas requiring aspiration. [27]

TREATMENT

Upto 30% of surgical site infections can show culture negative results on microbiological evaluation limiting the ability to provide good treatment. The reasons for such results include use of prior antibiotics, presence of slow-growing microorganisms and presence of bacteria in a biofilm configuration. [28]

There are three basic factors which are responsible for postoperative wound infection. They are: 1) Large number of bacteria's with necessary virulence; 2) Substrate on which contaminating microbes can live and propagate even; and 3) Host resistance due to impairment (be it local or systemic). [29]

The three important components of antibiotic prophylaxis are timing, selection and duration of antibiotic. [30] According to literature by Jain, et al. (2008), the role of antibiotic prophylaxis is still controversial as they found no reduction of post operative infections. [31]

The Recommended antibiotic for surgical site infection is first generation cephalosporin's particularly Cefazolin. [32] Clindamycin or vancomycin +Aminonglycoside, Aminoglycoside or fluoroquinolones+ Metrogyl are preffered drug instead of cefazolin in patients who are at low risk of MRSA and if β-lactum hypersensivity exists. [33] Surgical removal of devices is preferred in infections caused due to prosthetic devices because it cannot be controlled using antimicrobial drugs. [34]

Commonly Used antimicrobials drugs for Surgical prophylaxis [35]

Oral(Single dose given 1hour before procedure)

1) Amoxicillin 2gm (50mg/kg)
2) Cephalexin 2gm (50mg/kg)
3) Cefadroxil 2gm (50mg/kg)
4) Clindamycin 600mg (20mg/kg)
5) Azithromycin 500mg (15mg/kg)
6) Clarithromycin 500mg (15mg/kg)

} For patients allergic to Penicillin

Parenteral(Single injection just before procedure)

1) Ampicillin 2gms (50mg/kg)
2) Cefazolin 1gm(25mg/kg)
3) Vancomycin 1gm(20mg/kg) IV(in MRSA prevalent areas and/or penicillin allergic patients.)
4) Clindamycin 600mg(20mg/kg) IV (for penicillin allergic patient)
5) Cefuroxime 1.5gm(30mg/kg) IV + Metronidazole 0.5gm(10mg/kg) IV
6) Gentamycin 160mg(3mg/kg) IV + Metronidazole 0.5gm(10mg/kg) IV

} For Gut and biliary Surgery

Bratzler DW, Dellinger EP in 2013 establish guidelines for Antibiotic surgical prophylaxis by conducting a review of the ASHP therapeutics, IDSA, SIS and SHEA guidelines and Cochrane review and concluded that a single dose of cefazolin or ampicillin-salbactum is recommended for clean and clean-contaminated procedures with other risk factors. Alternative agent effective for patient with beta lactum penicillin's allergy includes vancomycin. [36] Bacteria's present in hospital environment are resistant to the antibiotics (Amoxycillin-clavulunate, ceftriaxone, cefuroxime, gentamycin) which are commonly used for surgical prophylaxis and also for empirical therapy of SSIs. Empirical therapy before antibiotic susceptibility test reports includes Amikacin and Piperacillin-Tazobactum or Amikacin and Cefoperazone-Sulbactum. [37]

Antibiotics used in surgical prophylaxis based on type of surgery [38]

Type of Surgery	Likely pathogens	Antibiotic choice	Dose
Gastroduodenal	Enteric gram negative bacilli, Gram positive cocci, Oral anaerobes	Cefazolin	<80kg: 1gm; 80-120kg: 2gms;
Biliary tract	Enteric gram-negative bacilli, Anaerobes	Cefazolin	<80kg: 1gm 80-120: 2gms;
Colorectal	Enteric gram negative bacilli, Anaerobes	PO: Cefazoline+Metronidazole Ampicillin/salbactum IV:Cefoxitin or Cefotetan	PO: 1gm+500mg 3gms 1gms×1
Appendectomy	Enteric gram negative bacilli, Anaerobes	Cefoxitin or cefotetan	<80kg: 1gm 80-120kg: 2gms;
Urologic	E-Coli	Cefazolin	1gm×1
Cesarean section	Enteric gram negative bacilli, Anaerobes, Group B Streptococci, Entercocci	Cefazolin	<80kg: 1gm 80-120kg: 2gms; >120kg: 3gms
Hysterectomy	Enteric gram negative bacilli, Anaerobes, Group B Streptococci,	Vaginal: Cefazolin Abdominal: Cefotetan or	1gm×1 1gm×1 or

	Entercocci	Cefazolin	1gm×1
Head and neck	S.aureus, Streptococci oral anaerobes	Cefazolin or Clindamycin	2gm 600mg
Cardiacthoracic	S.Aureus, S.Epidermidis, Corynebacterium, Enteric gram-negative bacilli	Cardiac: Cefazolin or vancomycin	1gm×1 15mg/kg
		Thoracic: Cefazolin or Cefuroxime or vancomycin	1gm×1 1.5mg 15mg/kg
Vascular	S.Aureus, S. Epidermidis, Enteric gram-negative bacilli	Cefazolin or	80kg: 1gm 80-120kg: 2gms; >120kg: 3gms
		Vancomycin	15mg/kg
Orthopedics	S. Aureus, S. Epidermidis	Cefazolin or Cefuroxime or Vancomycin	1gm×1 1.5gm 15mg/kg

Intraoperative antibiotic redosing intervals for prevention of surgical site infection [38]

Antibiotic	Redosing interval(hr)
Cefoxitin	2-3
Cefotaxime	2-3
Ampicillin/Sulbactam	2-4
Cefuroxime	2-4
Cefazolin	2-5
C;indamycin	3-6
Metronidazole	6-8
Vancomycin	6-12

CONCLUSION

Surgical site infection has become worldwide threat which mostly occurs within 30days of surgery. It has been found that there are no gender differences and is procedure specific. Staphylococcus Aureus was found to be common causative organism for SSI. Asepsis and Southampton wound scoring system has proved to be effective ways of assessing risk of SSI. First generation of cephalosporin's, particularly Cefazolin is most recommended antibiotic for SSI. Antibiotics cannot control infection due to prosthetic devices so surgical removal of devices is preferred.

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